The OPTICAL LANTERN

ANDREW PRINGLE

J. H. STEWARD'S

HIGH-CLASS

OPTICAL LANTERNS

For OIL, GAS, LIME or ELECTRIC LIGHT.

THE . . .

Davenport-Steward

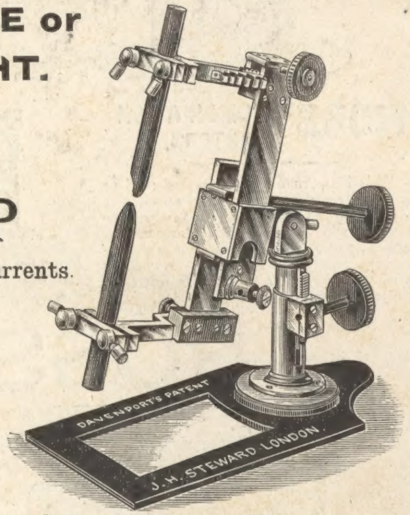
ARC LAMP

For Direct or Alternating Currents.

The BEST LAMP for Optical Projection.

Resistances of Improved Pattern—

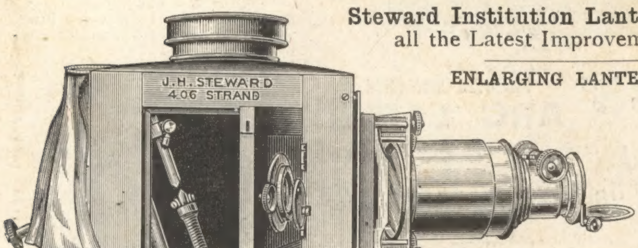
£2 15s. £4 10s.



Arc Lamp £5 5s.

Steward Institution Lanterns with all the Latest Improvements.

ENLARGING LANTERNS.



OIL (3-wick) **LANTERNS**
From £1 2s. 6d.

ILLUSTRATED CATALOGUES POST FREE.

406, Strand, W.C.; 457, West Strand, W.C.; 7, Gracechurch Street, E.C., LONDON.

A. Barclay
from
Albany

THE

Optical Lantern

FOR

Instruction and Amusement.

BY

Andrew Pringle, F.R.M.S., F.R.P.S., Etc.,

Late Vice-President Royal Photographic Society;
President Photographic Convention of the United Kingdom, 1889;
Author of "Practical Photo-Micrography," "Lantern Slides by Photographic Methods," and Joint-Author of "Processes of Pure Photography."

THIRD EDITION, REVISED AND CONSIDERABLY ENLARGED.

London:
HAMPTON & CO., 13, Cursitor Street, E.C.
1899.

PRINTED BY HAMPTON AND CO.,
13, CURSITOR STREET,
LONDON, E.C.

PREFACE TO THE THIRD EDITION.

SINCE the issue of the Second Edition, in 1891, many and notable improvements have been made on existing instruments, and several new apparatus and processes have been introduced. The object of this Third Edition is to bring the book up to date; and I venture to hope for the work in its latest form acceptance as flattering as was accorded to my previous efforts.

Being pretty fully occupied for a time with other matters, I was happy enough to secure the valuable help of Mr. W. B. Bolton in revising and adding to the matter contained in former Editions.

A. P.

Bexley Heath, 1899.

PREFACE TO THE FIRST EDITION.

It may fairly be said that this book fills a place not occupied by any other at present before the public. For the present treatise deals with the Optical Lantern only; it does so, I trust, as fully as is required for any purpose ; no attempt is made, as in other books on the "lantern," to give instructions for lantern-slide making, still less for the production of negatives. The present is, in fact, a lantern book, and a lantern book only. As such I hope it will be useful.

I have written less for the popular public lecturer than for the photographer and the teacher. If in any degree my writings popularise and simplify the use of the optical lantern, specially if they tend to give the lantern a *locus standi* as a permanent part of the paraphernalia of the lecture room, I shall be happy in the consciousness of having done some good.

ANDREW PRINGLE.

PREFACE TO THE SECOND EDITION.

The success of the First Edition, published in America, and the many requests of friends in England have induced me to offer this Second and cheaper Edition. I have tried to bring the book up to date, but as I have not been able to make personal experiment with every instrument on the market, I have elected to confine my remarks to such as I have used myself, no doubt to the unavoidable exclusion of many excellent appliances.

A. P.

CONTENTS.

The Optical Lantern.

CHAPTER I.

INTRODUCTORY.

WHEN we consider that in a coat pocket one can with ease carry a dozen lantern slides, and when we realise that each of these slides can be projected as a picture of (say) twenty feet square in size by means of an optical lantern, the utility and importance of this scientific optical appliance must be very evident. We should also consider the ease with which these lantern slides may be made, either by photography or by hand; we have also to take note of the variety of subjects amenable to reproduction as lantern slides, and we should further note that we are not even tied down to lantern slides as objects for the lantern, but that we may by our lantern project enlarged images of opaque objects, chemical and physical experiments, and microscopic preparations. When, finally, we find that all this is accomplished by an instrument which can be purchased by a moderate purse and carried by the feeblest hand, we are bound to own the merits of such an instrument, more especially because we know that what it pretends to do it does *well.*

No defence of, nor plea for, the optical lantern is needed in addressing circles or societies addicted to photography, for there are but few photographic memberhoods that have not their optical lantern, or at least their occasional lantern display. But most singular is the slowness of the progress in lantern use among

societies and in educational institutions not purely photographic. Since the first edition was written great advances have been made, and most learned societies and educational institutions use the lantern; there is still, however, much room for improvement in the instruments used or in the system of use. We know of establishments possessing good lanterns but without means for darkening their lecture-rooms, except with considerable trouble, during the daytime. The danger of misconduct by students in a darkened room has, as predicted in our earlier editions, proved to be imaginary. From a purely ocular point of view, diagrams, maps, blackboard designs, and the like, are inferior to the much larger and clearer lantern illustrations, and the shortsighted student must miss much of what the more fortunate normal-eyed may catch. But taking higher ground, it may be asserted that where it is important to study things as they really are, and not as the teacher is able to draw them, or thinks they are, or wishes them to appear, the optical lantern, with or without photography, must have the strongest claims on our attention. However well a physiological or pathological object may be drawn by hand, such a drawing is impotent to carry conviction and to impress memory in comparison with an enlarged photograph or an enlarged image of the object itself. When was ever a spectrum, drawn by hand and coloured by any method, able to compare with the actual spectrum projected on a screen by means, for instance, of an electric arc?

Many professors have admitted to the writer the claims of the optical lantern as a useful scientific appliance; some have owned that photographic lantern slides would be far superior to any other known method for educational demonstration; but each and all of these able men have been deterred from inaugurating the system we recommended by the most extraordinary and imaginative misgivings as to the cost of installation, and the difficulty and even danger of working the apparatus. The difficulty, strange to say, most commonly foreseen, was that of darkening the lecture-room—with a touch of doubt as to the conduct of young students in a darkened room—and there was the usual dubiety as to the safety of the gases used for the lime-light.

The prime object of this book is to remove dangers and difficulties from the imagination (for there alone they exist) of many

who are prepared to admit the advantages, but who question the practicability, of using the optical lantern as an educational and recreative instrument.

There are many persons, especially photographers and public lecturers, as well as philanthropists striving for the good of their fellow-men, who use the optical lantern, but they use instruments of such poor quality, and appliances so nearly obsolete, and they so little understand the means for getting the best results from the appliances they have, that the writer feels it no impertinence on his part to try to put "lantern matters" before the public in a succinct, and, as he hopes, clear and intelligible manner. He will endeavour to cover all essential ground, to reject all side issues, and to deliver himself in terms precluding possibility of mistake.

CHAPTER II.

GENERAL SYSTEM.

THE essentials of the optical lantern as a means for the projection of enlarged images from smaller objects on a suitable surface are very simple.

The optical system consists essentially of (1) a radiant; (2) a condensing system for collecting and concentrating on the object the light rays furnished by the radiant; (3) a projecting system for collecting, projecting, enlarging, and focussing the image of the object as illuminated by the rays from the condenser; (4) a "screen," or surface, for receiving the enlarged image and making it visible to the eye.

The entire system will be easily understood from Fig. 1. In this figure enough is drawn to show the general optical principles involved. The projection lens is made with an unusually large back combination not necessary with ordinary photographic lenses.

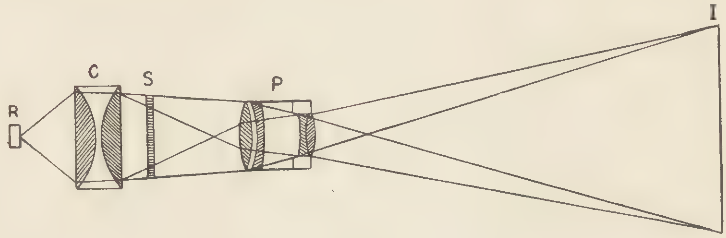


FIG. 1.

R, the radiant; C, the condenser; S, the lantern slide; P, the projection lens; I, the screen or plane where the enlarged image is received.

We may begin by describing what, in most cases, is the object to be illuminated and to be reproduced on a scale so much larger and at some considerable distance from the site occupied by the object. In the vast majority of cases this object is a transparent

positive picture on glass, and the size of the picture actually to be projected is usually about 3 inches, as the diameter of a circle, or 3¾ inches, as the diagonal of an oblong or square. For convenience, the glass plate is, in this country, invariably* 3¼ inches square, an opaque mask, having an aperture (circular or oblong), being used as a protection to the film of the "slide," and as a preventive of unsightly and superfluous light on the screen. The "slide" may be produced by photography, or it may be a hand-sketched design; for the present we will assume it to be a "transparent positive" on glass 3¼ inches square, with a mask having an aperture (circular or oblong) of the above dimensions—about three inches.

The radiant may be one of several kinds, but our chief consideration is that it may be a point of light, approximately, as the incandescent point on a lime cylinder: or it may have a surface of incandescence, or be formed of several such surfaces, as in a multiple-wick lamp. The more nearly the radiant approaches to a *point* the better, provided that the incandescence is sufficiently brilliant. The point of incandescence must be precisely in the focus of the condenser if the best result is to be obtained; enlarging the area of incandescence is a make-shift, and often a very bad one. Still, as oil lamps are used, and are often convenient, we must consider wicks as our radiant as well as limes or arcs.

The function of the condenser is to arrest as large a portion as possible of the rays of light from the radiant, and to cause them to fall equally upon all parts of the slide so as to produce, in the first place, uniformity of illumination. Passing through the slide the rays converge to a focus, at or near which point the projection lens should be placed in order that as much as possible of the light passing through the slide shall also be transmitted through the objective to the screen. From this it follows that, to obtain the highest result, the focal lengths of the condenser and projection lens must, within certain limits, bear a definite relation to one another.

The sharpness of the picture on the screen depends upon the slide and the screen being in the planes of the posterior and anterior conjugate foci of the projection lens; and as the screen, once erected, is to be considered immovable, while the position of the

---

*The American size is often 4¼ by 3¼ inches, or "quarter-plate."

projection lens varies with its focal length in its relation to the slide, the lens requires to have a certain amount of range of focus—that is to say, must to a certain extent be adjustable as regards its position with respect to the slide. More technically, the projection lens should have a rack and pinion focussing movement.

An optical lantern is simply a device for holding the radiant, the condenser, the slide, and the projection lens in suitable positions with regard to each other; and that the radiant may not directly illuminate the screen, nor interfere with the view of the spectators, the lantern usually takes the form of an oblong box—the light and part of the condenser being inside the box, and the slide-carrier and projection lens attached to the front. A lantern-box ought to be fairly light tight; and it ought to be as small as possible consistently with giving room for the radiant and not itself becoming too hot. In our opinion optical lanterns are made ridiculously large, though there has recently been a tendency to materially decrease the dimensions, but we hope in the future to see our lanterns for lime-light much more convenient and less weighty and expensive. With oil lamps we have to deal with the very important matter of draught or ventilation, which must govern the size of the lantern-box to a considerable extent.

The slide is usually held in the lantern, or passed through it, by means of what is called a "carrier"; the screen is often sustained by a "frame," or suspended from a roller. These details are not essential to the system, and will be treated later, each in its proper place.

CHAPTER III.

THE CONDENSER.

The condenser is used to collect rays of light that would without it be lost, so far as illumination of the slide is concerned. The radiant is at or close to the principal focus of the condenser, and the pencils of light travelling forward from the condenser in slightly converging lines should illuminate the entire aperture of the slide and fill the back combination of the projecting lens. Perfect parallelism is not attainable, because our radiant is greater than a point. The first matter we have to consider with regard to a condenser is its area, or, more conveniently, its diameter. A large condenser will illuminate a larger area of slide than a small condenser. But a large condenser requires to have a long focus practically, so that we lose light, as will be shown later. And, in the matter of focal length of condensers, we have always to remember that there is a limit of shortness of that focal length, for such a radiant as incandescent lime, not to mention an electric arc, cannot, without grave danger to the condenser, be brought nearer than, say, 2½ inches from it.

In practice, then, we have to choose between condensers having diameters of 3½, 4, and 4½ inches. If the reader will examine our figure, he will see that, in order to illuminate the

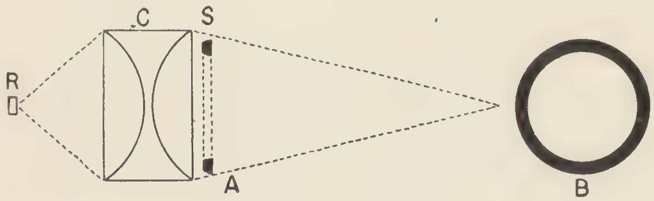


Fig. 2.

whole surface of a slide, the condenser must have an area at the very least equal to the surface area of the slide. If now our slide have a mask with a round aperture 3 inches in diameter, and

if the slide is pretty close to a 3½ inch condenser, the whole of the aperture in the slide will be illuminated, as in Fig. 2.

If, in fact, the whole of a 3-inch condenser were effective, and if the slide could be placed close up against it, a 3-inch condenser would suffice to illuminate a 3-inch aperture slide. But in practice the entire surface of a condenser cannot be made available, and we cannot as a rule place the slide close up

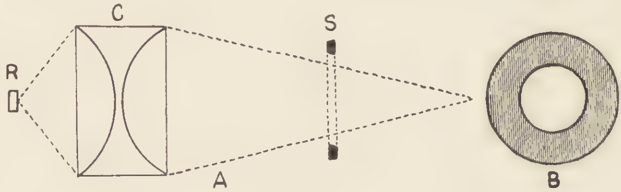


FIG. 3.

against it, and so we may take it that a 3½-inch condenser is the smallest practically available for a 3-inch aperture slide. In Fig. 3 we show the effect of an exaggerated distance between condenser and slide, A being a longitudinal and B a vertical section on the optical axis of the system. But suppose we have,

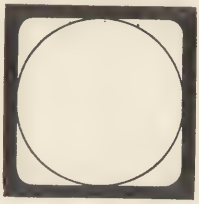


FIG. 4.

FIG. 5.

or intend to use, an aperture, say of the shape known as "cushion shape." A reduced plan of such a mask is given in Fig. 4, and we have placed inside it the disc of illumination from a 3½-inch condenser, on the same scale, but supposed to be not quite touching the slide. Plainly, taking the condenser of 3½ inches at its best, it cannot illuminate a cushion which in actual measurement has diagonals of 3¾ inches. It will, however, be found that a condenser of 4 inches diameter will cover the ordinary cushion-shape aperture, or the dome (Fig. 5), and so we may accept 4 inches

as sufficient diameter for a condenser for any picture on a 3¼-inch slide, provided that the slide be placed near enough to the condenser.

Some people seem to think that they will improve matters and make quite sure by using a 4½-inch condenser. There are still occasionally slides made, of the same size as a "quarter plate"—*i.e.*, 4¼ × 3¼ inches. These, with their masks, require a 4½-inch condenser sometimes, but we believe this size of slide is now practically obsolete; certainly it has no advantages over the commoner size, 3¼ inches square. There is a positive disadvantage in a 4½-inch condenser, which we must point out. It must almost necessarily have a longer focal length than a 4-inch, if aberrations and absorptions of light are to be avoided, and these in a condenser are most serious defects. The focal length may be taken for our present purpose as the distance between the radiant and the condenser.

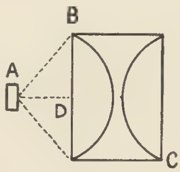


Fig. 6.

In Fig. 6, A is the radiant, B C the condenser, and A D the focal length of B C. With a 3½-inch condenser of any ordinary type the distance A D may be about 2½ inches; with a 4-inch, about 2¾ inches; with a 4½-inch, it will be about 3¼ inches or more. Now, according to the well-known law, the intensities of the light acting at D vary inversely as the squares of these distances—that is to say, the 4-inch condenser has the advantage over the 4½-inch one, in approximately the proportion of four to three. We cannot with safety shorten the focus of our condensers beyond the limits named (2½ inches), because with lime or electric light there would be the great danger of cracking the back combination by the heat of the radiant. So, to sum up, we may say that a 4-inch condenser is on the whole the best for general use. If only round apertures are to be used in the slides, a 3½-inch condenser will be better; if larger slides must be used, it must be larger. (See Chap. XXI.)

We now turn to the construction of the condenser. The simplest form is known as a bull's-eye, and consists of a single piece of glass plano-convex in form. Practically it is useless for our purpose; it is not achromatic, has gross aberrations, and is curvilinear.

The construction usually found nowadays is that of two plano-convex glasses, placed with their convex sides nearly in contact, as in C (Fig. 1). The pair of glasses are mounted in a brass cell which fits in the front of the lantern, and it is important that there should be air holes in the circumference of the cell, so that when the condenser gets heated the air may escape from between the glasses, and "sweating" be thereby avoided. The glasses, moreover, should be quite loosely mounted in the cell, so that on being heated they may have room for moderate expansion.

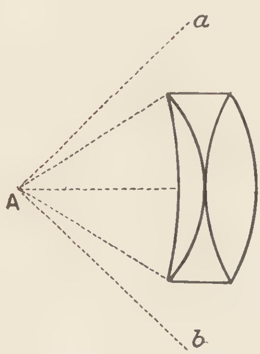


FIG. 7.

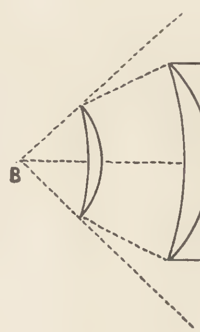


FIG. 8.

In the Almanac of the *British Journal of Photography*, 1888, we find the late Mr. J. Traill Taylor, a prime authority, recommending a form of condenser which we believe to be older than the one last described by us. This form consists, as will be seen from Fig. 7, of a plano-convex or slightly meniscated lens in close proximity to a double-convex. Mr. Taylor then rightly points out the loss of light certain to arise with this form of condenser unless the focus be long, which will entail loss of intensity, and he proceeds with his usual ingenuity to suggest the interposition of a third lens of plano-convex or meniscus form between the light and the doublet combination previously representing the entire condenser. The figures are Mr. Taylor's, and almost explain themselves.

In Fig. 7, *a b* represent rays that are lost, while in Fig. 8 they are refracted and utilised by the addition of the third and smaller lens. Mr. Taylor therefore concludes in favour of triple condensers.

Our experience is confined to the form first figured (Fig. 1) and the part of Mr. Taylor's Fig. 7. Of these we prefer the two plano-convex glasses (Fig. 1).

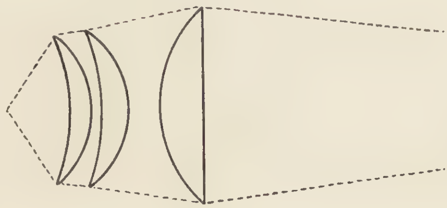


Fig. 9.

Fig. 9 shows a condenser devised by Mr. E. M. Nelson, and made by Mr. Baker, of High Holborn, London. This condenser, as will be seen, is a triple one, consisting of a meniscus next to the light, another slightly larger one in the middle, and a plano-convex next the slide. The focal length of this combination is so short that the light is only about an inch distant from the back lens, which is plainly dangerous for the latter. But this condenser gives a very good illumination, and is said to have better "corrections" than the ordinary condensers of commerce. Fig. 10 shows another condenser devised by Mr. Nelson, which has, possibly, a more extended sphere of usefulness than the shorter focus one of the previous figure. This, as is seen in the illustration, consists of three plano-convex glasses, and the focal length is this time great enough not to promise any danger to the optical parts.

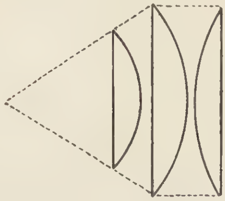


Fig. 10.

The condenser, Fig. 9, covers an angle of over 90°, and Fig. 10 an angle of over 80°. Each of these has an efficient area of 4 inches diameter.

Mr. Nelson has recently worked out a crown doublet, a triplet, and a quadruple combination of flint glass throughout, which are also, we believe, made by Mr. Baker. Of these the triplet and quadruple possibly give images of greater optical perfection, though they are necessarily expensive; but the crown doublet, which is shown in Fig. 11, can be recommended by the writer as practically perfect for ordinary projection work at a moderate price.

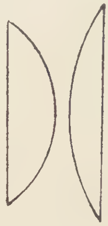


FIG. 11.

Messrs. Swift & Son, of Tottenham Court Road, now construct three sets of special lantern condensers suitable for use with projection lenses of 6, 8, and 12 inches focus respectively. These are made from optical flint and crown glasses from the factory of Messrs. Abbé & Schott, of Jena, and can be relied upon, therefore, as being of the highest quality and excellence. The combinations for use with the longer focussed lenses are worked out to give perfect results with the arc light, while that for the 6-inch lens is adapted to the mixed limelight jet.

A condenser, especially the lens next to the slide, must be of the most perfect glass—white, limpid, and free from bubbles, streaks, striæ, and scratches. Any mark, on the front element in particular, will show on the screen, to the great detriment of the picture. The greatest care must be taken to preserve the condenser from ill-usage and noxious vapours. The elements of a condenser, as already stated (especially the one next to the light), should be mounted quite loosely in their cells; they ought, in fact, to rattle on being shaken. And the various elements (especially the back one) should be ground to edges as thin as

possible. Both of these suggestions are made with a view to prevent breakage.

No condenser ever made will work well if the radiant be not properly centred, and carefully placed at its focal point. If the radiant in a lantern be out of centre the image on the screen will be unevenly lighted; if it be behind or in front of the condenser's focus there will be abominable fringes of colour round the margins of the disc on the screen. In oil lanterns the light is usually centrally placed in the optical axis, and the lamp has to be pushed and pulled till the focus of the condenser is found—as nearly as it may be found with a multiple-wick lamp.

Frequently, when a projection lens of long focus is used—say, 8 inches or over—a condenser of longer focus will also be required, which, as a rule, implies one of larger diameter. Thus with front

FIG. 12.

lenses of 8 inches or over we generally require to use our 4½-inch condenser. The reason of this will be evident to any reader who will trace the course of rays from an ordinary 4-inch condenser; he will find the rays cross before they reach the projection lens of long focal length.

Mr. W. I. Chadwick, of Manchester, makes a triple condenser, consisting of a small meniscus collecting lens and two plano-convex transmitting lenses placed with their flat sides outwards, as in the ordinary crown doublet, but with a series of interchangeable front lenses, by means of which the condenser may be adapted for use with objectives of different focal lengths. This arrangement, which is shown in the accompanying figure, will be found a great convenience as well as a matter of economy by those whose practice obliges them to use objectives of varying focus. The diagram, Fig. 12, shows the condenser with the interchangeable parts separated for changing.

CHAPTER IV.

THE PROJECTING LENS.

The "projecting," or, as it is often loosely called, the "front" lens, is in certain respects of no less importance than the condenser. It so happens that ordinary photographic lenses are in the main well adapted for use as projecting lenses for the lantern, and so as a rule there is little fault to find with the lenses used by one who is a photographer, or by a photographic society. But in the hands of the general public we often find projection lenses totally unsuited for their work.

A projection lens requires in particular three qualities. It must be accurately corrected for the visual rays of the spectrum; it must have a wide working aperture; and it must be free from spherical aberration. On account of the correction of a photographic lens, wherein the visual and chemical rays are made to coincide in focal point, such a lens as we have said is usually well corrected for the visual rays; but when a lens is only corrected for visual rays, and the actinic rays unheeded, that lens may be a splendid lantern lens, but cannot without modification be used as a photographic lens. A photographic lens of the type used for portraiture—in particular one of the rapid lenses invariably used in the days of wet collodion—meets practically every want of a projection lens. A portrait lens of the better class has usually a flat field, and area of aperture large in proportion to its focal length, so that we get a good picture on our screen with brilliant illumination. Decidedly, but not necessarily much, behind a portrait lens for our purpose, comes a so-called "single" lens, such as is often used in photography for landscapes; the chief drawback to this class of lens being that to secure a flat field we have to "stop down" the lens and so entail loss of light. Better perhaps than a portrait lens is a lens made specially for the lantern by several opticians, of whom we may mention Messrs. Dallmeyer, Swift & Son, and Wray, all of London. We are enabled to give a

diagram of a lens by Messrs. Swift, which we have worked, and it leaves nothing to be desired.

Some remarks as to the focal length of the projection lens seem to be called for. Given a certain distance from lens to screen, the shorter the focus of the lens the larger will be the disc on the screen. Given a certain lens, the nearer it is to the screen the smaller the disc. Given at a certain distance from lens to screen a disc too large, we can make it smaller either by taking the lantern nearer to the screen or by using a longer focus lens.

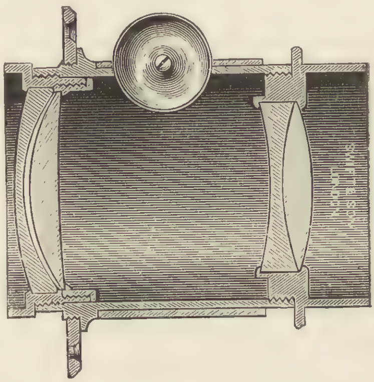


FIG. 13.

A 4-inch lens will give at any distance a disc just twice the diameter of that given by an 8-inch lens at the same distance. Mr. Chadwick gives a table that the writer has often found convenient. We quote it here:

Let S = Aperture of slide-mask in inches.
F = Focal length of projection lens in inches.
L = Distance from lens to screen in feet.
D = Diameter of disc in feet.

Then—

$$L = \frac{D \times F}{S} \qquad D = \frac{L \times S}{F} \qquad F = \frac{L \times S}{D}$$

Another useful guide to find the distance required from lens to screen, for a certain disc, is:—Calculate by how many diameters the disc is greater than the slide opening, add one to this number, and multiply by the focal length of the lens. Thus:—We require a 15-feet disc with a 6-inch lens; 15 feet is 60 times

3 inches, which we suppose to be our slide aperture; $61 \times 6 =$ 366 inches = 30 feet 6 inches, distance required from lens to screen.

It is for various reasons usually a mistake to choose a lens of very short focal length. If the room is small there is not much choice, but in a large hall we like to get as far back as we can up to 80 feet; at this distance a 12-inch lens gives a 20-feet disc. But beyond this we do not go if we can help it. If the lantern has, on account of shortness of focal length of lens, to be placed, say, 25 feet from the screen in a moderate sized hall, some people behind the lantern will be prevented from seeing properly, and the apparatus will probably be surrounded by part of the audience, which is objectionable and even dangerous if gas-bags are used, and is forbidden by many local authorities. Moreover, if the screen is placed on a raised platform the lantern has to be canted up and the screen tilted forward to an inconvenient degree; whereas, if the lantern were, say, 60 feet distant from the screen, the necessary cant and tilt would be much less, and the loss of light by greater distance is not nearly so great as some thoughtless persons seem to fancy, for the oft-repeated formula about the "intensity of light varying as the squares of the distances" does not hold here at all. The loss of light in enlarging a 3-inch disc to a 15-feet disc is, *cæteris paribus*, practically the same whether the enlargement be produced by a 4-inch lens or an 8-inch. But if our projecting lens has a focal length either so short or so long that its back combination fails to grasp some of the rays proceeding from the condenser through the slide, then surely we shall lose light (see page 19). By altering our condenser's focal length we may cram more pencils of light into a long focus front lens, but then we shall lose some of the pencils of light between the radiant and the condenser, or else have to remove the radiant further from the condenser, in which case our ancient formula *will* hold good as touching the illumination of the condenser itself. Reference to Fig. 1 will show at once that if the front lens has a very short focal length it will not catch all the pencils of light passing through the slide, unless it (the lens) has a very wide back combination; and again, if we get an aperture very wide in proportion to our focal length, we shall have a lens impossible to correct for aberrations. So, as usual, it is a case of give and take. We cannot have perfection in anything optical.

Speaking from experience, we may say that from a quarter-plate portrait lens of about 5¼ inches focal length to a lantern lens of 8 inches, we have no trouble in using our 4-inch condenser; with a 10 or 12-inch lens we have had to use a 4½-inch condenser; while with a very short focus lens we happen to possess, our 4-inch condenser does not work very well. We are perhaps safe in saying that, for all-round work, a lens of about 6 inches focal length, and a condenser of 4 inches, as usually made, will do as well as any other one-lens battery. The most useful lens we have for the lantern has a focal length of 9 inches; at 45 feet we get a grand 15-feet disc, using a circular slide mask.

CHAPTER V.

THE LANTERN BODY.

As already stated, the functions of the lantern-body, or box, are simple, and consist merely of holding the parts of the optical system together and enclosing the illuminant so that damaging rays of light cannot reach the screen to spoil the image, nor the eyes of the onlookers to dazzle them.

When the radiant is an oil lamp the lantern-body must be fairly large, for the lamp is sure to be of considerable size if a

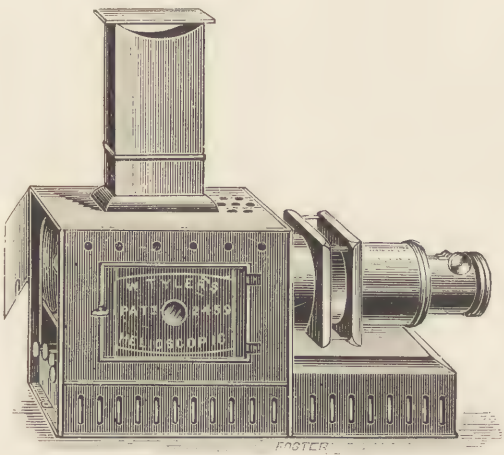


FIG. 14.

powerful one with, say, three wicks; there must be a certain amount of unoccupied space inside the lantern to give draught and adjustment room for the lamp; and, as a rule, the lamp requires a somewhat tall chimney to ensure draught. The body of the lantern is almost always "jacketed," wholly or in great part, in order to meet the great heat given off by the lamp; some-

times the outer jacket is of metal, sometimes it is of wood, the inner jacket being invariably metal.

Perhaps the first really business-like lantern introduced with any success was the now well-known sciopticon of Mr. Marcy, which in many points formed a standard for later modifications.

The double wick of the sciopticon lamp was soon found to be faulty in several ways, and a third wick was by various makers and in various forms added. Messrs. Newton greatly improved the performance of the lanterns of that day by placing a suitably curved reflector behind the wicks, their oil lamp being known as the "Refulgent." In most oil lamps will be found in front of the wicks a piece of flat glass to prevent breakage of the condenser. In our experience a well-arranged trio of wicks is better than two only; and we are informed that even five wicks have been successfully introduced. It must never, however, be forgotten that the number of wicks does not necessarily mean increase of effective light; and so far as our knowledge goes, we believe the best multiple-wick combination to be one of three wicks, placed longitudinally in the optical axis, the two outer wicks slightly inclined inward towards the centre one. The dangers with many-wick lamps are, great heat and a shadow down the centre of the image on the screen.

Serviceable oil lanterns are supplied by W. C. Hughes, of Kingsland; Clement & Gilmer (successors to Laverne), of Paris; Chadwick, of Manchester; Hume, of Edinburgh; and Lancaster, of Birmingham, from any of whom particulars of instruments in varying degrees of elaboration and costliness can be obtained on application.

But while a lantern-body for an oil lamp is necessarily of considerable size, we are convinced that lanterns for use with oxyhydrogen jets are usually made ridiculously large. Until quite recently the lantern, as usually made, was about three times as large and twice as heavy as it need be. With a lime jet there is no occasion for much unoccupied space, for no such draught is required as with an oil lamp; no chimney is required at all, and the only inconvenience to be feared is that of great heat. If the body be well jacketed—especially if the outer jacket be of wood—the total size of the lantern body may be very much less than it usually is without affecting in any way the performance of the apparatus. Fig. 15 shows a lantern made by Mr. Baker, of High Holborn,

and it embodies all the essentials of a perfect single instrument, though it is much smaller than the average optician's lantern.

The receptacle whereinto the "slide-carrier" goes should have its front provided with a spring sufficiently strong to hold the carrier in position while slides are being passed through. We propose to add to this part a couple of pinch screws, whereby the carrier, once in position, shall be clamped there. The space between the front of the condenser and the back of the "cone," or nozzle tube, to which the projection lens is screwed, is sometimes required for a water-tank, or other scientific article, whose image requires to be projected upon the screen. An "open stage" is easily devised, or a lantern specially adapted for such demonstrations may be used.

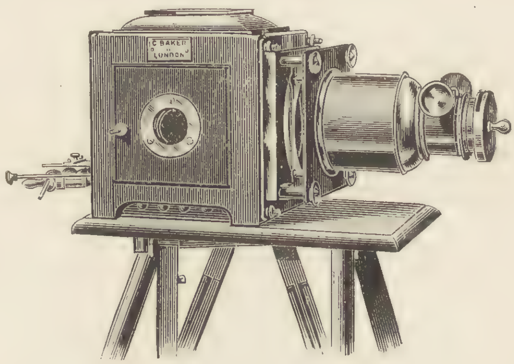


FIG. 15.—SINGLE LANTERN.

The projection lens is screwed, or otherwise fixed, to the "nozzle" of the lantern. This nozzle should "telescope" to a reasonable extent outwards, for on occasion a long-focus lens may be required, 8, 10, or even 12 inches focal length. It is very awkward to find that the nozzle will not stretch far enough for such a lens, when of necessity the lantern has to be a considerable distance from the screen. (If the lantern is to be used for "enlarging" purposes in photography there is all the more need for a long stretch of nozzle.)

Fig. 16 shows a very small lantern made for the writer by Mr. Beard, and now on sale by Mr. J. H. Steward. This miniature lantern packs into a box 7 × 6 × 5½ inches, and it has a 4-inch condenser and a good projection lens. It is fitted with a mixing

jet; and, in fact, is capable of any work that any other single lantern can do. For packing, the front simply slides into the body, Fig. 17. The whole lantern is of iron, except the front, which is of brass. In use it does not become intolerably hot if the jet is

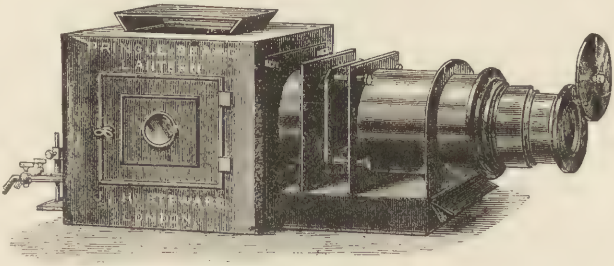


FIG. 16.—PRINGLE-BEARD LANTERN.

properly used; but of course we do not lay our hands on it during use. We have packed up our lantern within two minutes after extinguishing the light. Another advantage of this miniature is that it can be sold at a very moderate price.

FIG. 17.—SHOWING PRINGLE-BEARD LANTERN PACKED UP.

Messrs Newton also make a "miniature" lantern, and Mr. W. C. Hughes makes one with a cylindrical body. If the condenser be made square, the size of the body may be still further reduced; but as we can with ease carry our own lantern (packed with all its fittings, lenses, carrier, and jet) in one hand. There seems to be no cause for further reduction of size.

Lanterns have always side doors—sometimes on one side only, sometimes on each side. The door is usually provided with a window of coloured glass, by which the worker is sup-

posed to view the light without hurting his eyes. The writer has never yet been able to judge of the light through such a window, and has never felt any bad effect from looking directly at it with half-closed eye-lids, a way by which he *can* judge of the quality of the light. It is certainly necessary to have at least one door, which, however, during a display, should be very seldom opened. In every lantern the writer remembers to have seen there has been a considerable opening at the back where the jet goes in, and lecturers of any experience must have noticed the mischief caused by this opening if any of the audience happen to be seated behind and near the lantern. A person so situated can see next to nothing on account of the glare from the lantern. If the lantern have a wooden outer body a curtain of thick velvet should be fixed to the top of the back of the body, and hang loosely down over this objectionable opening. The lantern, Fig. 15, has at the back a door sliding in runners, and this door is pushed down after the jet is in position; but even this is not a sufficient protection in all cases. When the lantern body is of iron a similar piece of cloth may be hooked on to it by metal hooks, so bent as to make the curtain hang free of the hot metal body—if the body ever becomes hot enough to singe cloth, which ought never to occur if the lantern be properly arranged.

CHAPTER VI.

DOUBLE AND TRIPLE LANTERNS, DISSOLVING VIEWS, EFFECTS, ETC.

We now come to those edifices known by various names, and consisting of two or more lanterns made to work concentrically, which appear to be as necessary to the professional itinerant lecturer as they are useless to the scientific demonstrator or the photographic amateur, except in a few very rare cases. The chief uses of these multiple-lanterns are:—For what is called "dissolving" one picture into another, and for producing so-styled "effects," which are peculiarly the province of the popular public lecturer. Some of these "effects" are interesting, "effective," sensational, or really pleasing, and ought not to be despised. We allude to changes from day to night—from one season to another; while others, on which great ingenuity in slide-making is spent, do not come within the province of this book, nor touch those for whom this book is specially intended. There are some who think that in the display of a series of ordinary photographic lantern slides there is an advantage in "dissolving" from one view to the next; that is to say, these parties prefer to see one image die gradually away and the next on the list grow gradually in a weird or "uncanny" sort of way out of the ghost of the last, rather than to have one picture follow another in the natural way. For our part, we distinctly object to the dissolving business for ordinary slides; but provided the masks of the slides be all of one size and shape, the lanterns accurately registered, and the views or pictures reasonably adapted for such treatment (which they very seldom are), then by means of a double lantern the desideratum may be attained. And further, if it is deemed requisite or desirable to have the appearance of a curtain being drawn at the beginning of, and persisting throughout, the lecture, it can be achieved by means of a third storey, the lantern being then a triple, or more gloriously a "triunial," the top storey being sometimes lighted by oil. All these luxuries are

obtained only at the expense of a double or triple set of jets to look after, and to keep burning with equal brilliance—for if one disc is less bright than the other the effect is simply atrocious. If we are using, say, a double lantern, we have an arrangement usually very ingenious, often highly intricate, called a "dissolver"; if we are using gas in all three lanterns of a triunial the dissolver becomes a matter, sometimes, for a life-study. Still we do not seek to discourage the triunialist, nor to underrate the value of good "effect" displays.

In the early days of double lanterns, the two bodies were usually placed side by side, and the "dissolving" effected by serrated shutters in front of the projection lenses. We are indebted to the late Mr. George Smith, of the Sciopticon Co., London, for this detail sketch of the dissolver attached to his instrument. Of course there was a lamp in each lantern.

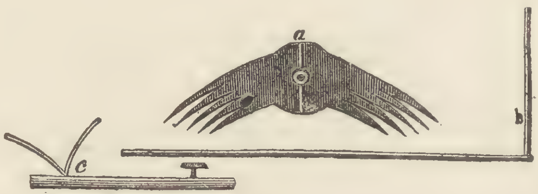


FIG. 18.—SMITH DISSOLVER.

The dissolver *a* is mounted on the arm *b* by means of a screw, as seen in Fig. 18, so as to cover alternately the lenses as it swings from side to side. The horizontal part of *b'* slips into *c* till the length of the united axle just allows the dissolver to swing clear of the lenses, and the whole is held in place by a socket spring at each end of the base-board.

The dissolver is operated by the handles at *c*, which are adjusted at the proper angle to limit the lateral movement of *a* to the distance between the lenses.

Now, however, *nous avons changé tout cela*, and we place the lanterns one on top of another. There must be an arrangement for causing the two discs to coincide precisely on the screen; this, of course, is managed by giving facilities for tipping the upper lantern down or lower lantern up, or both. Or the hinged parts may be entirely in front of the lantern-box proper, and the

tipping may include only the front plate and all it carries. The latter system is perhaps the most convenient. Double or

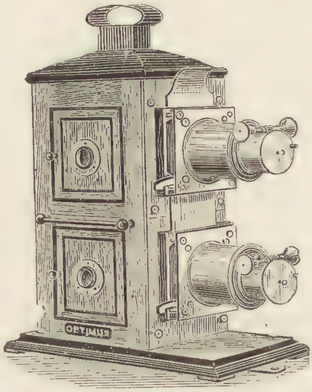


FIG. 19.—BIUNIAL OR DOUBLE LANTERN.

biunial lanterns are generally made all in one piece, and the two lanterns cannot be separated; but it seems customary to make

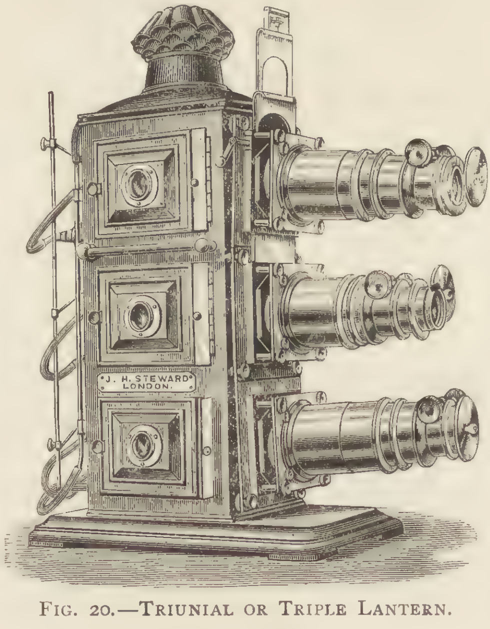


FIG. 20.—TRIUNIAL OR TRIPLE LANTERN.

triples in separate parts—the top lantern almost always can be removed—so that if we have a triunial we have three separate lanterns. So far as we have seen, the chief variations in these articles consist rather in the amount and finish of the brasswork, and in the price, than in any really essential qualities.

From what has been said, it will be readily believed that the arrangement for the distribution of the gases in suitable proportions to each jet, without loss of time or uncertainty from any one to any other of three lanterns, without waste of gas, must be a problem of considerable difficulty of solution. It is, however, excellently solved by more than one "dissolver."

This consists of a system of tubes or pipes, arranged in pairs, and communicating between each of the separate lanterns and the oxygen and hydrogen supply respectively. The individual

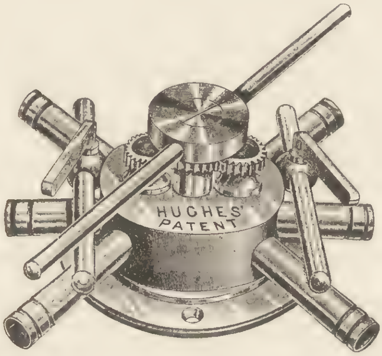


FIG. 21.—STAR DISSOLVER.

tubes are fitted with stopcocks to regulate the supply of each gas, and, when this has been carefully adjusted, there are usually one or more additional taps by means of which the flow of gases can be diverted to one or other of the lanterns as may be required, or, if necessary, shut off altogether, with the exception of the small quantity needful to prevent total extinction, for which a "bye-pass," subsequently referred to, is provided. This form of dissolver was originally introduced under the name of the "Malden," from its inventor, but is now manufactured in a variety of modifications by nearly every maker of lantern requisites under the generic title of the "Star Dissolver," from the cir-

cumstance that the system of tubes usually takes more or less the form of a star. The number of tubes depends upon the kind of lantern to be used, whether "biunial" or "triple," and the dissolvers are known as "four-way" and "six-way," according to the number of tubes they include in addition to bye-passes.

In all cases, of course, there must be a bye-pass on the hydrogen; in some cases there is a bye-pass on each of the gas tubes. With a pair of "blow-through" jets, for instance, it is necessary to have a bye-pass on the oxygen as well as the hydrogen. In testing a dissolver we have to note whether there is any noise in effecting the change, whether any time is lost before the second lime is fully heated, and whether any gas is wasted. A dissolver that requires only one hand to work is naturally preferable to a less convenient one.

CHAPTER VII.

ILLUMINANTS—OIL, INCANDESCENT GAS, ACETYLENE.

For small displays, undoubtedly the most popular, if not also the most convenient, form of illuminant is the mineral oil lamp; but its use is limited to discs of moderate dimensions, say, of not more than 9 feet or 10 feet in diameter. Formerly, the lantern in which a lamp burning colza or sperm oil was used could be considered as little better than a toy, although prior to its supercession by the more modern form a considerable amount of attention had been given to the improvement of the quality of the light. In its latest form the "fountain lamp," as it was called, consisted of a circular or argand wick, surrounded by a slightly tapering glass chimney, and so arranged that a free current of air passed through the centre of the flame. The oil was contained in a reservoir placed behind and slightly above the level of the flame, in which position the heat of the flame was advantageously utilised in raising the temperature of the oil and thus improving its illuminating power. The wick-chamber was connected with the reservoir by means of a tube, "trapped" in order to regulate the flow of the oil, but owing to the position of the reservoir above the level of the flame it was always a difficult matter to avoid overflow, and, consequently, mess. The more usual illuminants were colza, or, where expense was of less importance, sperm oil. To these were frequently added camphor and other substances to further improve the quality of the light. Camphine—a mixture of alcohol and turpentine, and a variety of similar compounds, were frequently used or recommended, but with very doubtful advantage, and colza oil may be safely regarded as the staple illuminant.

About five-and-twenty years ago, however, Marcy, of Philadelphia, introduced an entirely new form of lantern already alluded to under the name of Sciopticon, which formed the precursor of the modern style of instrument. Amongst other

important improvements it included a double-wick lamp burning paraffin or petroleum oil. This radical departure from previous practice, together with the arrangements made for the perfect combustion of the oil, wrought such an improvement in the degree and quality of illumination, that the oil-lantern began to assume a practical form for exhibition purposes on a small scale. The original Marcy instrument was still further improved by the late W. B. Woodbury, and introduced into this country by the Sciopticon Company, and a fresh impetus was thus given to the general use of the lantern.

Since that period the number of wicks has been increased to three, four, and even five, though it is questionable whether the gain in light with the larger number is commensurate with the great increase in heat and consequent inconvenience. Probably a well-arranged triple-wick lamp at the present day offers the greatest combination of advantages with the least inconvenience; at any rate, that is the form we should be inclined to recommend as the best all-round lamp.

A very efficient, and, at the same time, powerful lamp of 109 standard candle-power is known as Stocks's patent, and is obtainable through most dealers. It has four wicks, placed edgewise and at such an angle with one another that a very even illumination is given. It is fitted with a suitable reflector and a chimney adjustable as to height by means of rackwork, so that the draught may be increased or reduced to produce the best possible result. When a powerful oil-lamp is required this will meet the want.

One difficulty, and possibly the chief one from an optical point of view, with the multiple-wick lamp is the tendency to uneven illumination of the screen, owing to the area of the source of light and its want of homogeneity. In order to secure the greatest lighting-power the wicks are placed edgewise to the condenser, under which conditions there is a danger of the formation of dark streaks corresponding with the spaces between the flames; but this trouble is minimised as far as possible by a variety of ingenious modifications of the relative positions of the wicks and by placing them at such angles with one another as to cause them to present a practically uniform illuminating surface. Attention also to the important matter of a proper adjustment of the supply of air to the flame to set up perfect combustion aids not only

the quality and brilliancy of illumination, but further helps to reduce the inconvenience arising from excessive heating.

In order to reduce as far as possible the latter trouble, the body of the oil lantern is usually, or we may say invariably, in instruments of any pretentions to quality, "jacketed" or doubled in order to provide for a constant current of comparatively cool air passing between the two casings and thus reducing the heating of the whole arrangement. In the original Marcy lantern, as well as in many of the more modern ones, a sheet of plain glass is interposed between the light and the condenser to protect the latter, and in fact form a combustion chamber round which a current of cooler air is constantly playing.

It is needless to say, in view of the great amount of heat given off even under the most favourable conditions, that the selection of a suitable sample of oil is a matter of the utmost importance. Not merely on the score of quality of light, but more imperatively on grounds of safety, none but the best quality of oil should be used. The cheap low-flash samples are entirely out of the question, and even those of medium quality, that would be perfectly safe for ordinary household purposes, may prove a source of anxiety, if not of absolute danger, when used for optical lantern purposes. After all, the difference in cost is so slight that there is no inducement to wilfully employ the cheaper oils.

A serious objection frequently raised against oil lanterns is on the score of dirt and smell, but this we have little hesitation in saying is invariably the fault of the operator rather than of the lantern or system. If the wicks be kept properly trimmed and always burning at a proper height, and the inlets for air to reach the flame be kept clear and free from particles of burnt wick; but, above all, if every portion of the lantern be thoroughly wiped and no trace of oil allowed to run over, then there need be no fear of either dirt or smell. But if these precautions be neglected, the oil lantern will be a source of constant trouble and a nuisance wherever used.

Many have been the attempts made to adapt ordinary house gas to optical lantern purposes, but until quite recently, with but scant success. The comparatively poor illuminating power of coal gas, in proportion to the size of flame and amount of heat given off, has been altogether against the adoption of what would otherwise be perhaps the cleanest and most convenient

method of lighting we have. However, the introduction of the Welsbach incandescent gas burner, or rather, perhaps, the improvements made in that form of lighting since the last edition of this work was published, has brought gas within the bounds of practicability for projection on a small scale, and especially for enlarging purposes.

In this system an intensely hot flame on the principle of the Bunsen burner is caused to impinge upon a "mantle" or thimble-shaped framework of woven fabric impregnated with metallic oxides, such as zirconia or thoria; the mantle is thereby rendered incandescent and emits a light of extreme intensity with a relatively small consumption of gas. The principal inconvenience lies in the fragile nature of the mantle and its comparatively short "life." The system is, however, easily applied to any existing lantern, and though we have personally not had much experience with it, where gas is available we have little doubt that it will often be a convenience for small discs. The intensity of the light, the comparative smallness of its area, and its relatively low temperature, are all in its favour, though we believe there is often a difficulty in securing evenness of illumination owing to the tendency of the image of the "mantle" to project itself on the screen. When this occurs, however, we think it must be at least partly owing to a want of proper adjustment of the focal lengths of the condenser and projecting lens respectively. When it occurs and cannot otherwise be got rid of, it may be obviated at the cost of some loss of light by the intervention of a sheet of finely-ground glass—in the optical system, preferably between the light and the condenser. For enlarging purposes the loss of light may be practically ignored as it may be compensated by a slight increase of exposure, and the same expedient will often be found useful in the case of an oil lamp.

The latest aspirant for popular favour as a general illuminant is acetylene gas, and this is more particularly adapted to lantern purposes by reason of the ease with which it is generated as required, its intensity and high luminosity, the smallness of its flame and the relatively small amount of heat given off. When consumed under proper conditions and with a suitable burner, it will give a light equal to from 200 to 300 candles, which places it far ahead of the ordinary oil lamp for small exhibitions, and brings it somewhere to the level of the blow-through limelight jet. For

discs up to 10 feet in diameter, or for working up to 30 feet from the screen, it answers admirably, and even for larger shows is no doubt superior to a badly-worked limelight. For enlarging also it is particularly convenient owing to the whiteness and actinic character of the light.

Acetylene is a hydrocarbon—$C_2 H_2$—and was first prepared in the pure state, and as a definite compound by Berthelot in 1859, though as far back as 1836 it had been obtained by E. Davy in an impure state by the action of water on the black substance formed in the preparation of potassium. The earlier methods of preparation consisted in passing ethylene gas or vapour of ether, alcohol, aldehyde, or wood spirit through a red-hot tube, or by the action of red-hot copper upon chloroform. The gas thus obtained was purified by passing it through a solution of cuprous chloride, by which a red precipitate is formed, which, when decomposed by hydrochloric acid, gives off pure acetylene. But under these methods of preparation acetylene had not the least industrial value, and it was not until the accidental discovery by an American of a cheap method of production on a practically unlimited scale that it assumed any importance in connection with the arts and manufactures.

Berthelot had shown that acetylene could be formed by the direct combination of carbon and hydrogen by passing hydrogen gas over charcoal heated by the electric arc; but this again, with the appliances of the period was not a practical process, though at the present day somewhat similar means have been adopted with success. In the course of some experiments an American chemist, Mr. Wilson, had occasion to fuse together in the electric furnace lime and carbon, the result being a dark grey, slag-like mass which was thrown as waste into a bucket of water. Violent effervescence took place with copious evolution of a pungent and evil smelling gas, which on investigation proved to be acetylene and the fused mass from which it is obtained carbide of calcium. This in fact constitutes the modern process of manufacture. Carbide of calcium is first prepared by fusion together in the electric furnace of lime and carbon, the latter in the form of powdered coal or similar waste. This, when subjected to the action of water is decomposed, acetylene being liberated and slaked lime remaining as a residue.

$$2\text{CaÇ} + 2H_2O = C_2H_2 + 2\text{CaHO}.$$

The acetylene thus formed, if properly cooled and condensed or dried, is in a state of sufficient purity for ordinary illuminating purposes, though with some of the samples of inferior foreign carbide it is decidedly advantageous to submit it to a further course of purification. It forms a heavy colourless gas of strong unpleasant odour and specific gravity 0·92, or as nearly as possible double that of coal gas. It burns with an intensely brilliant, but if not properly supplied with oxygen, smoky flame. The latter is relatively small and the light white and extremely actinic in character, possessing from fifteen to twenty times the luminosity of coal gas, with which, light for light, it compares favourably from an economic point of view, being equal at current prices of the carbide to gas at 2s. 6d. per thousand.

Under normal conditions acetylene is not explosive and cannot be made to explode, but when mixed with a certain proportion of air, or when under a pressure exceeding two atmospheres, it becomes highly explosive. It also forms explosive compounds with copper for which reason no brass or copper should be used in the fittings. For these and other reasons probably based upon ignorance of the nature of the gas, various absurd and vexatious restrictions were placed upon the use of acetylene as well as the storage of calcium carbide by the insurance companies and the County Councils; but these have been in the main removed or considerably modified as increased knowledge of the necessary conditions was acquired and more perfect appliances for the generation and use of gas have been devised. The only remaining restrictions of any importance are, first, that for general illuminating purposes the generator must be fixed outside the building; and, second, that carbide in quantity must be stored, also outside, in properly constructed air and damp proof receptacles sanctioned by the County Council.* Small generators for lantern use, if satisfying the Council's requirements and quantities of carbide up to a few pounds are free from restrictions.

A very large number of generators of varying degrees of merit have sprung into existence, the difference consisting chiefly in the degrees of precaution taken to ensure efficiency and safety. The majority work on the principle of the floating gasometer, which rises as it fills and on rising lifts the charge of carbide out

* At the time of going to press, even these restrictions have been still further modified.

of the water and temporarily arrests the formation of gas until, by use, immersion again takes place and the process is renewed. In this manner only a small quantity of gas is stored at once but the process of manufacture becomes practically automatic and continuous, so long as any carbide remains undecomposed. In at least one form of generator the decomposition is set up by allowing water to drip at an adjustable rate upon the carbide, but the former plan seems in every way the preferable one. Additional arrangements have to be made for cooling and drying the gas in order to keep the supply pipes clear and also to prevent the admixture of air with the gas and the formation of an explosive compound, and it is in these details that the various machines chiefly differ.

FIG. 22.—"INCANTO" ACETYLENE GENERATOR.

The earliest and also one of the most efficient of generators is the "Incanto" of Messrs. Thorne & Hoddle, of Westminster. This is made in various sizes for general purposes but the diagram (Fig. 22) shows their pattern A which is specially designed for lantern purposes. It consists, as will be seen, of an outer water tank in which is fitted a rising gas holder in the centre of which is placed the carbide holder or generating chamber. When a charge of carbide is placed in the chamber and the apparatus filled with water, the gas is given off and collects in the holder, which immediately begins to rise and continues to do so until the carbide holder which rises with it is lifted out of the water, when the generation ceases, to be renewed when sufficient gas

has been used to allow the carbide to dip into the water again If the instructions supplied with the apparatus be strictly followed no attention is required after charging until the gas is exhausted and the charge requires renewings and the whole may be left alone when not in use. The smallest size takes a charge of 1¼ lb. of carbide equal to about 6 cubic feet of gas, and will work continuously with one burner for five hours or with a double one for two

FIG. 23.—ABINGDON SAFETY GENERATOR.

hours and a half. Other sizes will work respectively for twelve and thirty hours with single burner.

In Fig. 23 is shown the "Abingdon Safety Generator," as specially constructed for lantern purposes, with the generating chamber removed for charging, which operation may be performed while the gas is being used, as the gas-holder is fitted with a "water seal," which effectually prevents the escape of gas, either during use or when the generating chamber is removed. This renders the apparatus practically continuous in its action. Fig. 24 shows the same apparatus with the carbide cages removed from the generator and still further explains the internal arrangements. It is needless to say that in these, as in several other generators which we have not space to describe, the arrangements for drying and purifying the gas and for safeguarding against explosion are of the most perfect description, and the employment of acetylene under these conditions, whether for general illuminating or merely for lantern purposes, is absolutely safe in any ordinary hands. When it is

stated that the total weight of the apparatus varies, according to size, from 8½ lb. to 16 lb., its advantage over gas-bags or cylinders for small exhibitions is manifest.

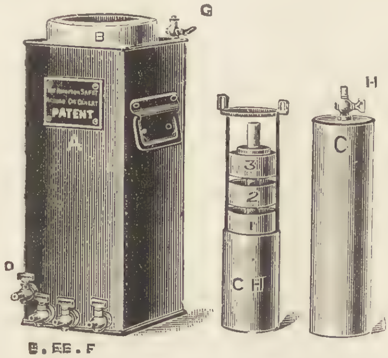


FIG. 24.—ABINGDON GENERATOR (showing Internal Arrangements).

In order to secure perfect combustion, and therefore the best result with acetylene, a special form of burner is necessary, or one passing a very small quantity of gas as compared with ordinary coal gas. With the latter the usual consumption per hour is about 5 feet, but with acetylene it is necessary to reduce the quantity to 1 foot by using a Bray's ooooo burner, the small consumption of

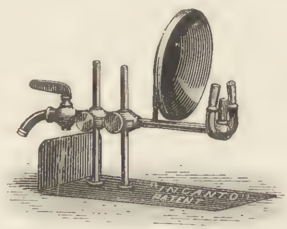


FIG. 25.—THREE-BURNER ACETYLENE JET.

gas and the diminutive flame being compensated by the extreme brilliancy of the light. This appears to be the maximum consumption of gas permissible from a single burner, though they may be had to consume no more than a quarter of a foot per hour. But to secure the very best illumination possible for lantern purposes very convenient arrangements of two or three burners have been

devised, and with these two and three hundred candle-power illumination is easily attained.

Fig. 25 shows a 3 burner fitting made by Messrs. Thorne and Hoddle, for which they claim 300 c.-p. This goes into the lantern in much the same way as a limelight jet, and is similarly

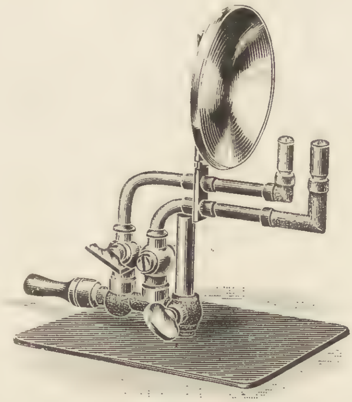


FIG. 26.—MOSS LANTERN JET.

adjustable and particularly easy to focus. In Fig. 26 we have the recently patented "Moss Lantern Jet," made by the Abingdon Acetylene Illuminating Company, which, besides the other adjustments, provides for the separate regulation of the individual burners, which means the getting of the highest efficiency out of each. This we believe gives 240 c.-p.

CHAPTER VIII.

ILLUMINANTS (Continued)—LIMELIGHT, JETS, ACCESSORIES, SATURATORS, ETC.

THE radiant most commonly used, and, as we think, the best to use in the optical lantern, is known as the lime-light, or sometimes as the oxy-hydrogen lime-light. A point on the surface of a disc or cylinder of unslaked lime is rendered incandescent by the action of an oxy-hydrogen blow-pipe. The lime is very "refractory"—*i.e.*, very difficult to cause to burn—but when it is rendered

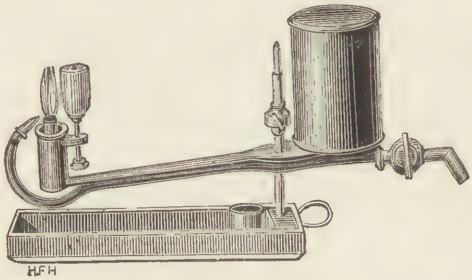


FIG. 27.—OXY-CALCIUM JET AND TRAY.

incandescent the light given out is very brilliant. There are "soft" limes and "hard" limes, the soft ones being rendered incandescent more easily than the hard ones, and so the former are used when the heating power of the blow-pipe is not very great, as, for instance, with the so-called oxy-calcium light, or the "blow-through" or "safety" jet. But to get the best result possible with the lime-light—*i.e.*, to get the greatest brilliance over the least area—we must use the hardest lime and a blow-pipe of proportionate heating power.

The oxy-calcium light calls for little remark; it is much less brilliant than the next higher light, the blow-through. In the oxy-calcium system we have a reservoir of spirits of wine and a tube from reservoir to nozzle, where there is an ordinary wick. The

spirit is lighted at the wick in the usual way, and a stream or jet of oxygen gas is driven through the flame to the lime, which is rendered incandescent, and gives a fairly bright light, estimated approximately at "150 candles." Fig. 27 shows the ordinary form of oxy-calcium jet and tray.

A form of spirit jet, introduced by Mr. J. M. Turnbull, of Edinburgh, is shown in Fig. 28. The reservoir contains methylated spirit, and oxygen is blown through the flame. In order to secure the best effect, the oxygen nipple should project an eighth of an inch inside the flame, and, of course, soft lime is required. The arrangement is shown by which the jet is kept level when the lantern is tilted. It gives a good light for small discs not exceeding ten or twelve feet.

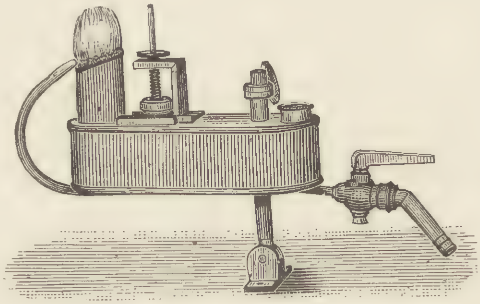


FIG. 28.—TURNBULL SPIRIT JET.

The blow-through jet comes next in order of brilliance of light attainable. The nozzle is made in slightly varying forms. In this form of jet we use a fairly large column or stream of hydrogen gas, either direct from the usual house supply or under a low pressure when compared with that of the mixing-jet. In or near the centre of this quietly burning stream of hydrogen is a small nipple, through which oxygen is forced at some pressure greater than that on the hydrogen; the oxygen is *blown through* the hydrogen flame, whence the name given to this jet, which is also sometimes called the "safety." A form of blow-through jet which gives as good a light as any known to us is one made by Messrs. Newton. The estimated power of a good blow-through jet is 250 candles; but the disadvantages of this system are that the area of incandescence is generally large when

the greatest total of light is given off, and the light is apt to be red in tint.

An excellent jet on the blow-through principle has been more recently introduced by Brin's Oxygen Company, and this leaves little to be desired when circumstances admit of the employment of the weaker form of light.

The same gases are used in the mixing-jet, but both are usually under high-pressure, and they are mixed in a chamber before they emerge from the nipple where they are lighted. The reason for the nomenclature is thus evident, and on the completeness of the mixture of the gases depends in a great measure the amount of heat, and consequently of light produced.

During the winter of 1895-6 a couple of evenings were devoted by the members of the Photographic Club to a trial of gas jets and several instruments of very high efficiency were shown and photometrically measured by Mr. C. E. Hearson. The

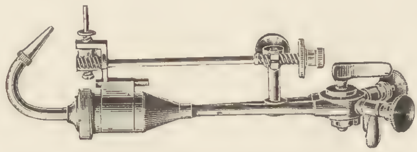


FIG. 29.—GWYER JET.

best results—and there was practically but little to choose between them—were given by a new jet devised by Mr. Gwyer of Bristol, and manufactured by Messrs. Willway & Sons, of the same place, and two or three others manufactured by Messrs. Ottway & Sons, of Clerkenwell, but operated at the trial by different gentlemen. Mr. Gwyer's jet, of which we can personally speak in the highest terms, is shown in Fig. 29. It is made of various powers, the No. 2 shown in diagram being of, approximately, 2000 candle-power. But, as already remarked, there is not much to choose between it and Mr. Ottway's, which is shown in Fig. 34.

In order that we may obtain the very best results, certain principles must be attended to in the construction of all kinds of jets where the gases are under pressure, however low.

In the gas-way there should be no sharp turn or acute-angle corners; even in the mixing-chamber the "jostling" of the gases may be too violent. We do not ourselves recommend the putting

of any obstacles whatever in the gas-way. Many jets by the best makers contain near the mixing-chamber pieces of fine gauze. Whether this is intended to insure effective mixing of the gases, or whether it is put there with an idea of greater safety, we cannot say; but we invariably remove and throw away the gauze. Some makers have themselves admitted to the writer that they know of no advantage belonging to the gauze, but that it was put there in deference to public opinion only. In connection with this point we have to note that Messrs. Newton and others have effected a decided improvement in mixing-jets by placing in the mixing-chamber, alternately, perforated discs and rings of metal. Many other substances have at one time or another been put in the gas-way—cotton, wool, shot, powdered pumice-stone, and even lengths of cane—but for what object, unless to cause failure and danger, we have never yet been able to ascertain.

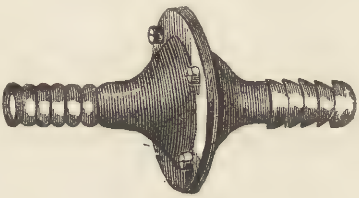


FIG. 30.—CHADWICK SAFETY VALVE.

With ether tanks and such arrangements there must be value in any device that will prevent a suck-back of gas, or will extinguish gas if sucked back lighted. We would not, however, be misunderstood with regard to our position on the ether-oxygen question. Accidents have certainly occurred with ether, but in these cases the ether has almost always been "loose," either in the liquid state or escaping as vapour. For "saturators" the volatile fluid should always be taken up by absorbent material such as wool or cotton waste, as in devices described later (pp. 54 *et seq.*). With the volatile so used and with saturators of the latest designs we do not expect to hear of any accident, provided reasonable care be used.

There should be no obstruction, then, in the gas-way; but if there is to be obstruction at all, the gauze alluded to will do little harm. The discs and rings of Messrs. Newton are valuable, and a certain safety-valve may give confidence to a timorous worker. We show such a valve in Fig. 30; by means of a simple internal

arrangement gas is allowed to pass one way only. We believe Mr. W. I. Chadwick devised this.

A very important point toward the production of a good result is the angle at which the gas-stream impinges on the lime. A simple diagram (Fig. 31) will illustrate this.

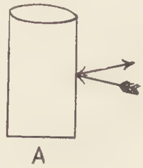


FIG. 31.

A and B may be taken as extreme cases. If the angle of impact be such as suggested at A, the nipple of the jet would come between the point of radiance and the condenser, and, in fact, there would be a shadow of the nipple on the condenser. Moreover, the lime would be worn into a very deep "pit," which always hurts the light and endangers the condenser, because the little brilliant pit might have its heat focus on the condenser, and even the flame itself might glance off the lime at such an angle as actually to strike the condenser. On the other hand, in B the gas-stream impinges on the lime in such a slanting manner that the impact would be very imperfect, and there would be a want of "grip," so to speak. Mr. Lewis Wright, a great authority in such matters, worked out the theory and practice of this subject, and as a result Messrs. Newton produced a mixing-jet which has given excellent results in our hands (Fig. 32). As this jet shows some novel features we shall have to recur to it.

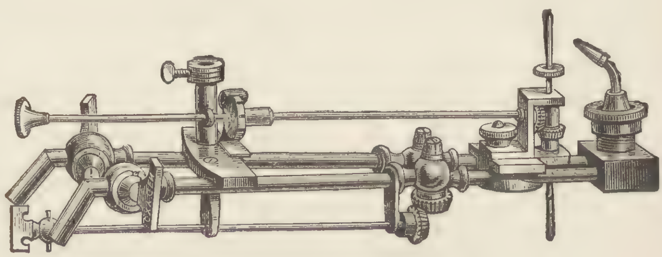


FIG. 32.—NEWTON MIXING JET.

The bore of both tubes and nipples varies in different makers'

jets, but it is impossible to lay down any laws on the matter. Perfection of light depends not on any absolute or isolated item, but on the proper adaptation of one part of a system to another. In particular, it may be said that the pressure of gases regulates all other conditions. A small-bore tube may give a better light than a large bore, at a less expenditure of gas, if the pressure happens to suit the smaller tube. A large-bore nipple works at a decided disadvantage if the pressure of gas be not up to a corresponding point. Doubtless the very best light is to be got from a large bore with a great pressure. Perhaps the greatest mistake made in ordinary practice is having a bore too large for the pressure. For general use the calibre of both tubes and nipple should be small rather than large.

Everyone who has worked with lime-light knows the unpleasant effect of "hissing," "buzzing," "whistling," or "roaring" by the jet. These noises may be due to various causes—improper proportion of the gases to each other, incorrect position of the lime in relation to the nipple, pitting of the lime, &c.; but the commonest cause is roughness in the tubes or nozzle, protrusion of shreds of metal into, or square corners in the gas-way—in fact, any rough edge or unevenness inside the tubes. Sometimes the noise may be stopped by cleaning, or broaching, or riming out of the tubes, but sometimes jets are so badly made that noise is inevitable at any pressure over a very low one. Any jet may be noisy under certain conditions, and should not, *ipso facto*, be rejected on account of noise. If it be a good one otherwise, but is noisy, it should be examined, cleaned out (rimed out, if necessary); failing these remedies, if the noise is intolerable it may be rejected, but reduction of pressure is likely to obviate the trouble.

The "nipple" of a jet sometimes screws on to the nozzle, sometimes is in one piece with it; sometimes is entirely of brass, sometimes has a platinum tip let into it. Some first-class lanternists find no advantage gained by the platinum tip, while others advocate it. If the tip is used, it must be properly adjusted to the brass, so as not to form a projection into the gas-way. Sometimes in very powerful jets the platinum-tipped nipples lead to trouble, on account of the platinum separating or burning out from the brass. In our opinion the bore of the nipple should be an uninterrupted cone in shape.

All taps and fittings, especially of a mixing or high-pressure jet, should be of the best manufacture and finish. The nozzle is often removable from the mixing-chamber—a very good plan—but the collar by which the junction is made must fit accurately and be tightly screwed up. There should never be any leakage, even under the highest pressures.

Jets are sometimes made "interchangeable"; that is, are supposed to act either as a blow-through or mixing by a change of nozzles. We do not recommend this form of jet—the same kind of "chamber" is not well adapted for the two systems.

It is always important to know at the very instant, and without possibility of mistake, which tube conveys the oxygen and which the hydrogen. Often, too, it is important to know by touch as well as by sight. Accordingly we recommend that one tube be blackened and the other left bright. Further, we advise that the two taps be of different shapes. Our own practice is to have the H tube black and its tap the common T shape, while the O tube is bright and has an "arm-tap," which, moreover, we roughen or nick with a file.

As the impact of the burning gases on a limited area of the lime sooner or later bores a small hole in the surface—in technical language, the lime becomes "pitted," or a "pit" is formed—and as this pit not only spoils the illumination but endangers the condenser, it is important to have a good system and apparatus for turning constantly or frequently a new part of the lime's surface to the action of the gases. The more powerful the blow-pipe heat the more frequent the necessity for a fresh lime surface. With the most powerful jets it used to be considered almost essential that the lime be constantly turning; this was usually effected by clockwork. With an average mixing-jet and pressure the lime ought to be turned at least once every minute. But with a blow-through jet of ordinary power the lime-point does not attain its full incandescence till the gases have played upon it for, say, one second, and in this case the lime ought not to be turned so often. We have some very crude methods of turning the lime as well as some very neat ones. The old inconvenient method consisted in opening the lantern door and turning the "chair" round with the hand. Nowadays the chair is usually operated by a rod and some kind of cog-wheel arrangement, the rod being long enough to protrude backwards to the outside of the lantern, in a

manner shown in all our figures of lanterns with jets. Mr. Place, of Birmingham, designed an exceedingly good quick-motion action for the lime turning. Messrs. Newton further improved this by adding a check, or click action, the effect of which is that the points presented consecutively to the gas-jet follow a regular spiral course round the lime cylinder, the eighth pit being directly below the first.

Fig. 32 shows a detail not yet explained, but, in the opinion of competent judges, a valuable addition to a jet. Below the jet proper may be seen a rod with a T-piece at one end, and operating toothed wheels under the jet tubes. In each of the two tubes is placed an extra tap, that on the oxygen tube being a complete "cut-off," while that on the H tube is a "bye-pass," allowing a small quantity of hydrogen to pass even when the tap is turned off as far as it will go. The two taps work equally, and are simultaneously operated by means of the rod and the toothed wheel attached to it. If now these two taps be turned full on by means of the cross, or T-piece, and if the light be then adjusted at its best by means of the ordinary jet taps, it may be turned down by the "cut-off" arrangement—the hydrogen will continue to burn a small flame, and the lime will be kept hot, and when the full light is required all that is necessary is to turn up the "cut off" to its full extent. Thus—first, gas is not wasted; second, an experienced hand may regulate the light, turn it down and leave it —any person, however inexperienced, may then turn up the "cut off" and find the light just as the expert arranged it; third, the *proportions* of the gases being maintained, the total brilliance of the illumination may be regulated by one motion—where miscellaneous slides are being passed through a lantern (some dense, others thin), this facility of regulation will be found of value. This "cut off," devised by the author, is made by Messrs. Newton, of London, and others.

Several manufacturers make arrangements similar in intention but dissimilar in execution.

Lime-cylinders are very apt to crack during an exhibition, and a lime once cracked never gives a perfect light. Considering that draughts of cold air acting on the lime cause this cracking—undoubtedly the case often—Mr. E. G. Wood, of London, devised a "shield" of metal, a little wider than the lime-cylinder, and long enough to protect it even when turned to its highest point. Of

course an opening in the side of the shield allows the gas to impinge upon the lime.*

Most persons of a mechanical turn of mind will notice the very insecure way in which the jet is usually fixed to the pin, or standard, forming part of the "lime" tray. The jet is fixed in such a position that the slightest force on the long arm of the lever may uncentre the whole jet. Few attempts have apparently been made to improve this matter, but, Mr. Pumphrey, of Birmingham, has an arrangement worthy of notice. (Fig. 33.)

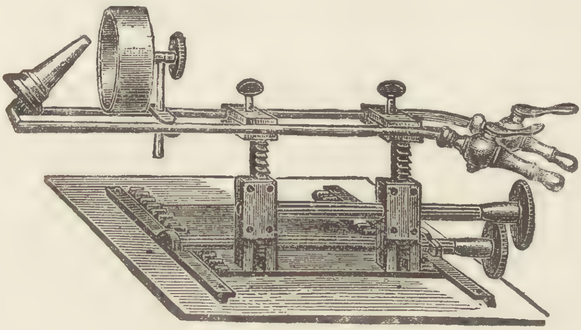


FIG. 33.—PUMPHREY MECHANICAL STAGE.

Here, in Mr. Pumphrey's "mechanical stage," we have the usual backward and forward sliding motion of the tray, and also a raising and lowering rack as well as a "traverse" and a double grip of the jet. The figure also shows the receptacle for lime-*discs* —seldom used now, so far as we know.

Lately several makers have produced jets and trays with traversing and other motions for the centering of the jet. We would specially mention in this connection the "Premier" jet and tray of Mr. J. H. Steward, and an arrangement of Messrs. Newton & Co.

Fig. 34 shows the rack-work and other arrangements now used by the writer. The jet is by Messrs. Ottway, and is mounted on a strong upright. The whole jet is steadily and accurately raised or lowered by means of a rack and pinion; the side adjustment is regulated by a special mechanical movement easily accessible to the

*The fireclay lime-case described in the appendix acts also as a protection for the lime against cold draughts.

hand. When the proper position is found, the whole jet is firmly clamped in place by a screw for the purpose. The position of the lime with regard to the nipple is regulated from the outside of the lantern. The "tray" carrying all this apparatus slips backwards and forwards in grooves of triangular section in the lower part of the lantern body. This figure also shows the writer's "stand-by" arrangement, whereby, during a lecture, a fresh lime can be brought into action without lowering of the light. This will be found very convenient for lectures of considerable duration.

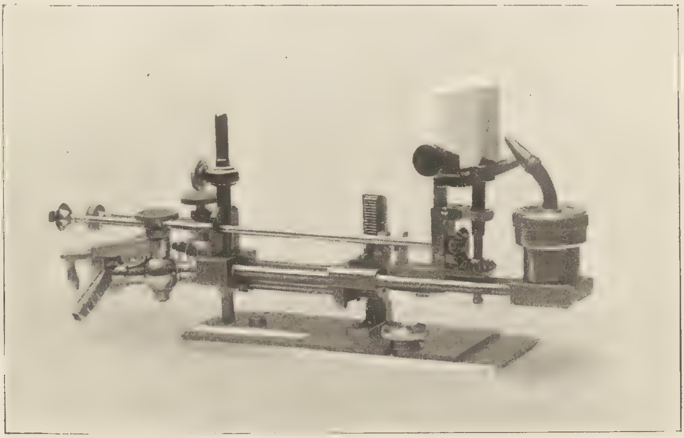


FIG. 34.—OTTWAY JET AND MECHANICAL STAGE.

When a good supply of coal gas can be obtained from the ordinary house main, it may be convenient to use this supply and dispense with a cylinder of coal gas. A jet has been devised by the Manchester Oxygen Company (Jackson's patent) to work under these conditions, and is known as the "Injector." By special arrangements in the mixing chamber a full stream of oxygen is caused to suck a sufficient supply of coal gas through the jet, and the result is a limelight of much greater power than is obtained with an ordinary blow-through jet. It is necessary to have a full pressure of oxygen and a good free supply of coal gas, and the regulator on the oxygen cylinder must be adapted to give extra pressure, or may be omitted altogether. There is no danger of oxygen being forced into the house pipes, because the stronger the draught of oxygen the greater is the suction on the coal gas tube. Extra strong rubber tubing should be used for

the cylinder, and the gas-way for the coal gas should be of full size. We have seen a remarkably fine light produced with this jet; it is often convenient, and always saves the expense of compressed coal gas or saturators.

Tanks or "saturators" for use with ether and other volatile liquids are frequently used, and, as they are very convenient when hydrogen is not obtainable, we shall describe one or two contrivances, drawing attention, however, to the danger incurred if carelessness creeps in, and to the fact already mentioned that we do not expect any gain of light over that of a good mixing jet. The principle on which saturators all work is this: Oxygen is passed over ether—which may be either sulphuric or "petroleum"—or other suitable volatile liquid, and in passing becomes saturated with the vapour, and is then conducted to the H tap of the jet, while part of the oxygen passes directly and without saturation to the O tap. In some tanks the ether lies in divided chambers, over which the oxygen passes; in others flannel or a similar material is thoroughly saturated with the liquid, and the oxygen passes over or through layers of the damp fabric. Of the earlier forms the "Broughton" tank was of the former type, the apparatus being divided into a number of compartments into which the ether was poured; while in Ives's saturator the container was packed with flannel to absorb the ether. The late Mr. Albert W. Scott introduced a saturator for use with ordinary benzoline or similar liquids, in which flannel was used to absorb the liquid, and a small lamp was fitted outside the container to slightly warm the surrounding air, and so promote the volatilisation of the liquid.

But, despite a vast amount of attention lavished upon saturators by, amongst others, the late Rev. T. F. Hardwich, it was long before they gained any marked favour, owing to the great uncertainty attached to their use. One of the first of the really reliable ones was the "Optimus" of Messrs. Perken, Son & Rayment, which fitted inside the lantern, and in which not only were the conditions of working scientifically dealt with, but a higher degree of efficiency was attained than heretofore. With this form of saturator, however, unless specially made for the lantern, or the lantern for it, it was a troublesome job to adapt them to one another.

Of late years very much more attention has been turned to saturators, with the result that perfect control of action, absolute safety, and an efficiency, at least equal to mixed gases under the best conditions, has been attained. In fact, given a really good form of

mixing jet, many operators are of opinion that an efficient saturator will afford a better result than the mixed gases.

In Fig. 35 we give a diagram of the "Pendant Saturator,"

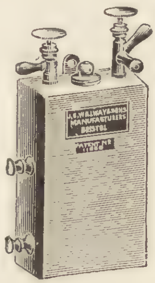


FIG. 35.—PENDANT SATURATOR.

manufactured by Messrs. Willway & Sons, of Bristol, one of the latest and most efficient instruments of the kind. This is constructed to work outside the lantern, being suspended from a nail on any convenient part of the stand, and is therefore available for use with any lantern without special adjustment or adaptation. It can also be used in conjunction with any mixing jet, which, however, should be preferably packed. Gwyer's jet, manufactured by the same firm, is specially recommended. In this instrument the difficulty arising from the blowing of ether into the jet tubes, or sucking it back into the cylinder tube, has been entirely overcome, and absolute steadiness of light ensured. One great trouble with saturators has been in connection with the filling, both in using the right quantity of liquid, and more especially in getting rid of the less volatile and useless residuum that remains after the really valuable portions have been taken up by the oxygen. The first portion of this difficulty is overcome by the provision of an overflow plug, shown at the left hand side of the diagram; no matter whether quite exhausted, or only partially emptied when last used, there is no uncertainty as to how much ether is required for refilling, as it is simply poured in at the "filler plug" until it runs out at the overflow. Then, again, with most saturators it is extremely difficult to get rid of the heavy residuum already alluded to, the only available means being to dry it off by heat, which is a tedious operation. In the "Pendant" saturator this task is performed by the simple process of

blowing out, the lower plug on left hand side of the diagram being opened, and an ordinary bicycle tyre pump screwed on to the "filler" aperture at top, when in a very short time the whole of the waste liquid is blown out. The frequency of the blowing out will depend on the liquid used, and the amount of work done, but working every evening with ether of *s.g.* ·717 the makers recommend the blowing out to be done once a week. If gasoline be used instead of ether the blowing out will require to be done more frequently. These are the only two liquids recommended with this saturator, benzoline and methylated spirit being alike unsuitable. The blowing out should be performed in the open air.

With this saturator the makers claim to be able to get at least as good a light as with mixed oxygen and hydrogen, and as they employ it in their extensive works in preference to the mixed gases for testing jets, their practical conclusion should carry some value. Charged with one pint of ether, the "Pendant" will keep a large-bore jet supplied for four hours at least.

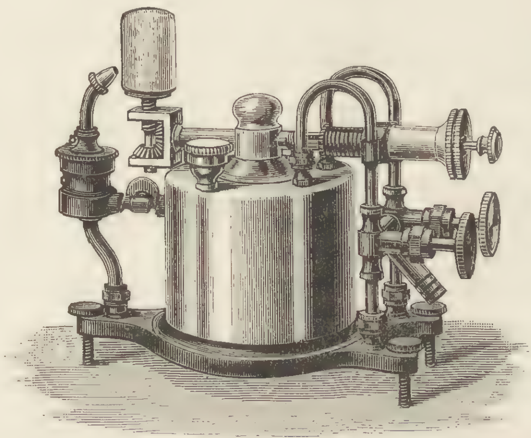


FIG. 36.—GRIDIRON SATURATOR.

In the "Gridiron" Saturator (Fig. 36), we have another form for use inside the lantern. This is compactly and solidly made, and, when finally fixed in position and centred, is perfectly rigid and permits the lantern to be tilted in any direction with safety and without fear of the light working out of centre. It is silent

in action and will work with one charge for about two hours and a half; and it is claimed for this instrument, also, that it gives as good a light as the mixed gases with wide-bore jet. The three screws in the base of the stand serve the purpose of levelling or of raising or lowering the light, but for accurate centring a mechanical tray (not shown in the diagram) is supplied at a slight extra cost. This instrument, as well as other appliances for lantern purposes, is made by Mr. F. Brown, of Gate Street, Lincoln's Inn.

Amongst other saturators of modern type, which we have not space to fully describe, we may mention the "Lawson," which is capable of good work.

In using a saturator it is necessary, in the first place, to exercise care in the selection of the liquid employed, which should be of the highest grade obtainable. In recommending ·717 ether, it will be obvious that any higher specific gravity must contain more water, and that this water remains behind to saturate the material forming the packing of the saturator, and to raise the specific gravity of the next charge, and lessen its efficiency. And, moreover, after a few charges have been exhausted, the saturator will become so charged with water as to be useless. Quite similarly with benzoline or other liquids, the lighter portions are taken up by the oxygen, and the heavier non-volatile portion remains behind to be pumped or dried off.

Always be careful to properly fill the tank, especially for a long run; as with a nearly exhausted saturator there is a great tendency to small explosions, which, if not dangerous with modern instruments are at least startling. Be careful also to pump out or dry off the tank at regular intervals in order that it may always be in an efficient working condition.

In turning off the light always be careful to turn off the saturator taps before shutting off the general supply of gas.

If these simple rules be followed, and a good saturator used, it will be found decidedly more convenient than using the gases in separate cylinders, whether at home or travelling.

CHAPTER IX.

PREPARATION OF OXYGEN AND HYDROGEN, AND STORAGE IN BAGS.

ALTHOUGH during many years past improvements in the methods of producing and storing oxygen in a compressed state in cylinders has virtually put an end to the practice of home manufacture, we feel that a work like the present would not be complete without some instruction for the benefit of those who are beyond the range of oxygen pumping stations, or who from any other reason are unable to maintain a regular supply of compressed gas. It has therefore been decided to continue in the present edition the instructions which have appeared in previous issues.

Chlorate of potash heated to a fairly high temperature will yield oxygen, but the evolution of the gas in such a case is apt to be unsteady and difficult to control. If, however, "black oxide of manganese" (manganese dioxide) is added to the potash salt, the gas comes off at a lower temperature and more steadily. But when the manganese is used, a certain amount of chlorine comes off with the oxygen; and this chlorine, being destructive to india-rubber bags, and even to metal fittings (as taps and tubes), should be as far as possible eliminated before the oxygen reaches the bag, or gasholder, where it is to be stored. The chlorate of potash and oxide of manganese—the mixture being sometimes called "oxygen mixture"—are heated in a retort made of metal; the oxygen, with its accompanying chlorine, is passed through water containing a substance which abstracts the chlorine; thereafter the oxygen is sometimes dried over sulphuric acid, sometimes passed direct into the bag or other receptacle for storage.

The chlorate and manganese do not combine in the oxygen mixture, nor does the manganese undergo any permanent change during the heating, but is probably converted for the time being into permanganate of potash, which is at once decomposed. After the operation of gas-making the manganese oxide remains,

and can be used again, if it is considered worth the trouble of washing and drying what remains in the retort. Manganese dioxide gives off oxygen at a red heat, but is not, so far as we know, used for this purpose.

The usual instruction for making oxygen gas is to take 4 parts of $KClO_3$ (chlorate of potash) and 1 part of MnO_2 (manganese dioxide) and mix them. These proportions are a very good average; but our own practice is to take the required amount of $KClO_3$, and stir up with it MnO_2 until every crystal of the former is black with the latter. The mixing should be done with a wooden or bone rod or spatula, not with a metal instrument. As a rule the $KClO_3$ is pure enough as sold, but sometimes the ignorant or unscrupulous trader adulterates his MnO_2 with soot or charcoal, and sometimes by accident sulphide of antimony is substituted for or mixed with MnO_2. Either soot or antimony present in the retort with the chlorate would be a source of great danger, but the mixture may be very easily tested. Let a few grains be placed in a test tube and held over a flame, and if on gentle heating little sparks are seen, accompanied perhaps by a slight crackling, the mixture is correct; but if there is a flash or a little explosion, it is dangerous. When $KClO_3$ is bought in bulk there is almost always mixed up with it a quantity of organic matter, bits of wood, paper—we have even seen moss; these must be carefully removed, as they might lead to trouble in the retort.

One pound avoirdupois (16 ounces) of the oxygen mixture will yield 4 cubic feet of oxygen—theoretically it ought to yield rather more, but we never could get more out of it, using ordinary chlorate of potash of commerce, which is good enough for the purpose. Some years ago it was suggested that in place of, or in default of MnO_2 common kitchen salt may be used. And certainly this is the case; if the chlorate be pounded along with the salt, or the salt carefully mixed with the pounded chlorate, the oxygen comes off very gently and steadily, and the yield of oxygen in proportion to the chlorate is good. Iron rust or sand, and doubtless other substances, may be used for the same purpose as MnO_2, and we note that Mr. Hepworth* uses both MnO_2 and salt. We find nothing works better than $KClO_3$ blackened with MnO_2.

* "The Book of the Lantern." By T. C. Hepworth, F.C.S.

The mixture being ready is placed in the retort. Fig. 37 shows the kind of retort that we can recommend from experience. The body is conical in section, made of wrought iron, brazed and riveted. The neck screws on to the body and a washer of mill-board or felt impregnated with asbestos is placed between body and neck. Sometimes the bottom is made of copper, but this costs more and is unnecessary. At the top may be seen a small cylindrical projection; in this is placed pretty tightly a cork, and so a safety-valve is obtained. If any stricture occur in the gas-way the cork will be blown out. The neck of a retort should never have a square turn, but always be rounded, as in Fig. 37.

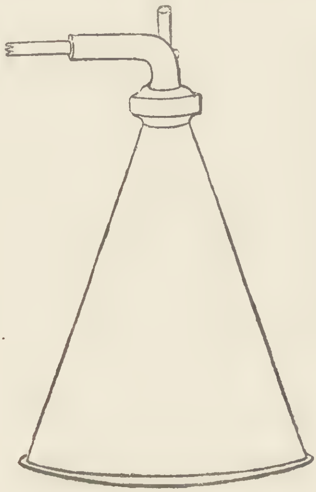


FIG. 37.—OXYGEN RETORT.

No violent heat is needed to drive off the oxygen, in fact, too much heat, especially at first, retards operations, seeming to cause the mixture inside to form a cake, with an outside more or less impervious to heat. The retort may be put on a dull red fire, but we prefer a gas burner such as that made by Fletcher, of Warrington, under the name of "radial" burner. A coke stove makes a good heating appliance, and even an apparatus with a very large wick, known as a "lamp stove" may be employed. But the radial gas burner is probably the best. If by sinking it in a suitable receptacle over the burner the heat

can be made to surround the retort, so much the better, especially if there be a large quantity of "mixture" in proportion to the size of the retort.

From the retort the gas passes along the neck-tube to a purifying bottle. This may be any wide-mouthed bottle, having a bung through which pass two tubes of metal. The retort neck is connected by a rubber tube with one metal tube of the purifier, and this dips below the surface of water to near the bottom of the bottle. The second tube has one end inside the bottle but well above the liquid and the other end outside, and connected by a

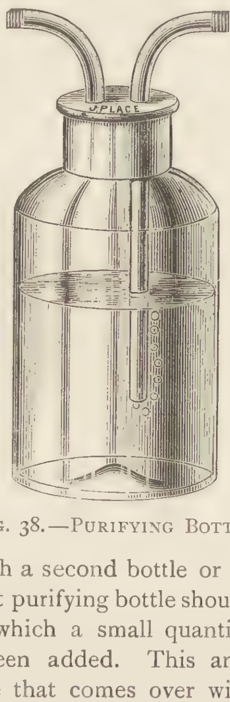


FIG. 38.—PURIFYING BOTTLE.

rubber tube, either with a second bottle or directly with the gas-bag or tank. The first purifying bottle should be about two-thirds filled with water, to which a small quantity of caustic soda or caustic potash has been added. This and the water remove nearly all the chlorine that comes over with the oxygen. If a second bottle containing a similar solution be used the gas will, after passing through it, be practically free from chlorine, as may be verified by the absence of the peculiarly unpleasant smell of the latter gas. Carbonate of soda or of potash will answer almost as well as the caustic alkalis. A good indiarubber bung is to be preferred to any metallic cap or fitting, as it acts as another

safety valve; and a glass purifier is better than an opaque one, as it is well to observe at what rate the gas is coming off as shown by the bubbling inside the bottle.

It is well sometimes to dry the oxygen before putting into the storage receptacle. For this purpose the second purifying bottle may contain a small quantity of sulphuric acid, but of course in this case both ingress and egress tubes are kept above the surface of the acid. This process of drying is rarely necessary; a second solution of alkali, or even a quantity of plain water is, however, of considerable utility.

Having mixed the $KClO_3$ and MnO_2 as described, and placed the mixture in the retort, and the retort on the heating apparatus, the system is connected all along, the retort with the first purifier, this purifier with the second if two are used. But the last purifier is not connected with the gas-bag or gas-holder. Before connecting any two parts of the apparatus it is desirable to *blow through each separate part* to make sure that there is no obstruction in the gas-way. The neck of the retort is to be screwed pretty tightly on to the body, the safety-valve cork pressed firmly but not violently home, and the retort is to be supported in such a way that it cannot be overturned, one fatal accident is said to have occurred through the overthrow of a retort, and consequent clogging up of the neck by the heated mixture.

As the retort is gradually heated a slight crackling may be heard, and probably an occasional bubble, will rise in No. 1 purifier. Presently a slight rush of air may be perceived at the free end of the arrangement—viz., at the end of the rubber tube which, later, is to be connected with the bag.

A piece of brown paper or some such material is now lighted by means of a match, the flame if any blown out, and the smouldering paper held in the current of air passing from the free end of the tube. A lighted pipe or cigar is useful and often handy for this test. The presence of oxygen in the current will easily be verified by the paper or cigar bursting into a peculiarly bright flame. The gas-bag—if such is to be used—should previously have been as nearly as possible emptied of air; to do this, fold the bag up with the tap open and kneel on it or otherwise press all the air out, shutting the tap instantly. The moment before connecting the tube with the oxygen now issuing from it, the tap

of the gas-bag is to be opened; this is sometimes forgotten, and leads to a safety-valve being blown out. The bag should be on a level higher than the purifiers, for sometimes when gas comes off rather violently water gets blown into the tube leading out of a purifier, and water in a bag would be rather out of place. The oxygen is now allowed to come off steadily; if ever the evolution becomes violent the heat should be lessened either by lowering the gas in the burner, or by taking the retort off the fire or stove. The heating must not be violent at first, as above stated. Very likely after a time the evolution of oxygen will stop and appear to be finished, but if the proper quantity of oxygen has not been obtained (see above) the retort should be shaken or receive a smart knock, or may be turned partly on one side; and often even if it be left alone the oxygen will, of its own accord, begin to come off again, though the pause may have extended over several minutes. The bag may be filled "drum-tight," it will probably be less tight after the oxygen in it has cooled. A little deftness is needed if the bag be full before the oxygen has ceased to come over. When the bag is nearly full the heat on the retort should be lowered, but not entirely removed; when it is desired to stop operations, the gas-bag tap is closed, the tube connected with it instantly removed; the heat removed from the retort and the tube below water in the first purifier *immediately* pulled out of the water. If this be not attended to, the water from the purifier will be sucked back into the retort, which will be burst in all probability. Retorts should not be of cast-iron, but of wrought metal, which will rip but not fly to pieces.

As soon as the retort is cold it should be well washed out with water; changes of water are to be put in until it comes out quite clear. The manganese, as stated, may be collected by filtering; in any case it is apt to make a very nasty mess if the contents of the retort are poured out into a sink. The beginner should examine the contents of the retort at this stage; if he finds any unaltered chlorate of potash he will know that his mixture was not exhausted. Large cakes in the retort are a sign of over-violent or over-rapid heating.

Hydrogen Making.

Pure hydrogen gas is stated to give with the lime a better light than ordinary carburetted hydrogen, such as is used for house illumination. Our own experience leaves us in doubt on

this point, but our trials were made with a kind of house gas not common, as it was made directly from paraffin oil and merely purified by water.

It is very easy to make hydrogen practically pure. Scraps of zinc are placed in the bottom of a Woolff bottle having two necks. Into one neck is fitted a rubber bung bored to take a long thistle-head funnel reaching well down into the bottle. The other neck has also a bung fitted with a bent tube, reaching an inch or two inside the bottle and connected outside with a water purifier as for oxygen, which purifier is connected with the hydrogen storage receptacle. Into the thistle-head funnel dilute sulphuric acid is poured (acid one part, water four parts), when the hydrogen will be given off at the delivery tube. The funnel-point must, of course, be below the surface of the liquid in the bottle. The purifier contains plain water.

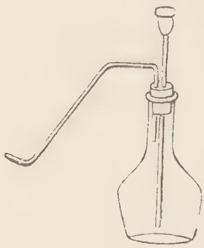


FIG. 39.

A flask with double-bored rubber bung may be used in place of the Woolff bottle, as in Fig. 39.

With gas-bags "storage" is hardly a proper word to use, because the less time the gas is stored in a bag, the better for the bag and for the light. But we may have to put the gas into a bag for immediate or early use. For a person making his own gas at home there is the alternative of a bag or a metal "holder" or "tank," and in practice the bag will be found the more convenient, if the "lantern display" is to take place away from home; but if the gas is to be used at home, then the metal holder has the advantage.

Gas-bags are made of "indiarubber cloth," that is, of rubber lined outside and inside with some kind of cloth. Generally the

inner lining is of canvas, the outer of a stuff known as "twill." A gas-bag is usually of wedge shape, and in the middle of the thin end of the wedge is let in a tap. The manner in which this tap is let into the stuff of the bag, often makes all the difference between a good bag and a bad one. The tap should screw into, or be soldered into, a large, pretty thick plate inside the bag; if the plate is not thick but inclined to have sharp edges, the bag will sooner or later be cut by it. Two qualities of bags are usually sold, the better quality is invariably cheaper in the end. But the better quality is not always dearer to purchase, for we know second-rate bags made expensive by the quality of the outer cover. The best bags the writer has ever used are plain black outside, and have taps properly let in, and so made as to be locked with a padlock when it is desired.

Bags are made in various sizes, a convenient one holds seven cubic feet of gas, and may be thirty-six inches long, twenty-eight wide, and have a wedge-depth of twenty-four inches. For a very long lecture or for unusual pressure the bag may hold about ten cubic feet, and be 40 × 32 × (wedge) 28 inches. Gas-bags used to be made rectangular, and are sometimes so made still, but the wedge is the usual and the better shape.

In order that the pressure may be applied to the bag or bags they are placed between "pressure-boards." If the blow-through jet is in use the oxygen bag is placed under pressure and hydrogen from the main is used; so also with the oxy-calcium light, one bag only is required. With ether-oxygen and benzine-oxygen one gas only, oxygen, is used under pressure. In these cases a single pair of pressure-boards is required. But as double pressure-boards answer also for single bags, we recommend the purchase of double boards.

The bag or bags are placed in the jaws of this contrivance, the taps projecting through the hole cut out for them at the apex of the board-wedge. The bags are to be pushed well home into the jaws of the pressure-boards, and the partition, usually of strong sail-cloth, separates the two bags if two are used, or is allowed to lie flat if only one bag is in use. After the bags are in position the strap at back is to be tightly pulled and securely buckled, to prevent the bags from springing backwards. The support in front of the board will be found necessary when the bags are large and full; but it is hinged and folds out of the way when not re-

quired. Pressure-boards must be of strong wood, and the hinges at the apex must be very strong. On the ledge near the top are placed the weights. These may be twenty-eight pounds or fifty-six pounds each, and should be flat and not round. If any danger can be said to exist in working the mixed gas jet, it may be said to lie in the possibility of the weights falling off the pressure-boards, and so causing a suck-back of gas. Therefore the weights should be tied on to the ledge in some secure way, more especially if they are round weights. We recommend the worker at home to have fifty-six pound weights made of lead or iron with a very broad base.

In computing the pressure on the gas we have nothing to do with the size of the bags, though it is very common to see calculations on this basis. It must be borne in mind that the actual pressure varies with the position of the weights on the top board, as they exert greater leverage the further they are placed from the hinges In fact, with wedge-shaped bags, as commonly used, it is next to impossible to establish any rule based upon pressure per square inch. With the seven-feet bag suggested, and a top board of, say, 40 × 28 inches, one hundredweight, if placed as far as possible from the hinges, or on the thickest end of the wedge, ought, with mixed gases, to give a very good light indeed. For a "blow-through" jet, fifty-six pounds weight on the pressure-boards (40 × 28 inches) ought to suffice.

Gas must not be kept long in rubber bags; such prolonged storage is bad for the bags and bad for the light. The sooner it is used after it is made the better. Oxygen kept twenty-four hours in the best bag will give a very poor light, as we have repeatedly found. Even four hours has in our experience made a marked difference in the light. Presumably hydrogen also deteriorates in the same way, probably to a greater extent. Even such a septum as india-rubber cannot prevent diffusion by osmosis, and, moreover the bags themselves suffer seriously by having gas kept in them. Immediately after the "display" or lecture is over the gases ought to be forced out of the bags, the latter being folded and kneeled upon after removal of the taps. If the inside of an old bag be examined the effects of oxygen will easily be observed.

Oxygen may be stored for a considerable time over water in a metal tank, but even under these conditions it deteriorates after a time. Moreover, if the metal of the tank be not thickly tarred

or painted the oxygen will attack it. We need not figure a metal tank which consists merely of a small edition of a gas-holder, or what is for some reason unknown to us called a "gasometer," so often seen at public gas works.

Before leaving the subject of bags we would say that if in cold weather they become very stiff they should be warmed before being filled with gas. The taps should be kept working "sweetly" with vaseline, or some such lubricant. If a bag happens to get a hole in it, the owner would do well to have it repaired by an expert rather than at home.

CHAPTER X.

STORAGE OF GASES IN CYLINDERS. REGULATORS. GAUGES.

SINCE the manufacture of oxygen, and its storage in metal cylinders at high pressure became in Great Britain an established and successful industry, the use of gas-bags has to a great extent fallen into desuetude, and, indeed, when we compare the advantages and conveniences of the two systems of storage, there is not much wonder that bags are rapidly dying out. It is long since oxygen and other gases were first stored in cylinders, but when the Brin's Oxygen Company started to make and trade in oxygen at prices far below the previous quotations, the use of their gas and metal cylinders rapidly gained the ascendancy, and "compressed" gases will probably oust gas-bags entirely in a few years. Another matter that has greatly popularized the cylinder system was the invention by Mr. Beard of a regulator so effective, simple and cheap, that we do not hesitate to stamp it as one of the most satisfactory inventions ever made in connection with the optical lantern.

Barium monoxide gently heated in air takes oxygen from the air and becomes barium dioxide, thus:

$$BaO + O = BaO_2.$$

If now the air supply be cut off and the temperature raised, the BaO_2 gives up part of its oxygen and reverts to its original state BaO, and these changes can of course be repeated time after time by regulation of air and temperature. All this has long been known, but nobody seems to have been able to devise machinery for utilising these reactions until Brin's Oxygen Company came before the public with their patent machinery. On Mr. C. H. Bothamley's authority the writer states that the following are the requisites for success in this system of oxygen-isolation. (1) Proper regulation of temperature. (2) Perfect purification of the air from carbon dioxide, CO_2. (3) Presence of a certain definite amount of moisture in the air. (4) Mainte-

nance of a low pressure in the retorts. The furnace is ingeniously made to regulate its own temperature by the expansion or contraction of metal bars acting on "dampers." CO_2 is eliminated from the air by caustic soda and lime; the air is then dried or damped according to necessity, and passes over the hot BaO in long convoluted cylinders; the oxygen is got from the now BaO_2 by raising the heat, the nitrogen having been collected or allowed to escape. The awkward part of the business was formerly to get rid of the nitrogen; but this difficulty has been overcome, and the gas prepared by Brin's process may now be accepted as practically free from nitrogen.

The gas is now forced at a very high pressure into metal cylinders. These cylinders are of wrought iron or steel, and should be tested to a point of pressure greater (say three times) than what is to be actually used. In England the cylinders are usually charged to a pressure of "120 atmospheres," or 1,800 pounds to the square inch. To give an idea of the result we may state that in a cylinder thirty inches by five and three-eights, weighing twenty-eight pounds, we can have forty cubic feet of oxygen; while ten feet of gas, ample for the most prolonged lecture, can with ease be carried in one hand.

Hydrogen gas is also compressed into cylinders in the same manner as oxygen by all the compressing companies, so that the lanternist is now entirely independent of the supply of house gas.

It will easily be understood that when we have gas under such pressure as 1,800 pounds on the square inch, there is a certain amount of difficulty in managing it, tubes are apt to be blown off and there is a danger of leakage at all points not solid metal. The valves of these cylinders, therefore, require to be very strongly and accurately made, and a system for regulating the pressure of gas outside the cylinder becomes necessary. The latter desideratum is thoroughly well fulfilled by a small and simple apparatus, Beard's patent Gas Regulator. By using this contrivance, which is fixed on the valve tube of the cylinder, the gas can be turned on full without opening the jet taps and without tying the rubber tubes to jet tubes. This of itself is an enormous gain, for the gas can be turned on at the cylinder or cylinders and then adjusted in proportions as required at the jet. Provided there is sufficient pressure of gas in the cylinder to keep the regulator open, the gas

comes in a steady stream. Fig. 40 shows the external and internal arrangements of Beard's regulator.

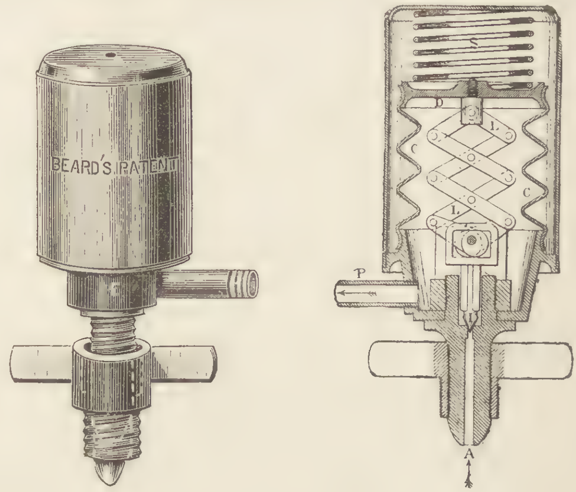


FIG. 40.—BEARD'S REGULATOR.

A pressure gauge is also frequently useful to show the rate at which the gas is being used, or to indicate at any time what amount of pressure, and consequently—the internal dimensions of the cylinder being known—what amount of gas there is in the cylinder. A cylinder fitted with these two contrivances may be put down as perfectly suitable and convenient for all purposes.

It must be noted that in adding regulators and gauges to the gas-storage system the chances of leakage are always increasing; every joint must be very tightly screwed up by a "spanner" or other instrument of like nature nature, or hammered up.

A rule usually observed, and most useful, is that the two cylinders for O and for H are painted in different colours. The oxygen cylinder is generally black or very dark, the hydrogen a bright red.

As an additional security against filling the gases into wrong cylinders the plan has been adopted by the Brin and other companies of having the filling valve of the O and H cylinder fitted with right and left handed screws respectively so that it is a physical impossibility to fill the O cylinder with H or *vice versa.*

On next page we give a table showing capacity, size, and pound-pressure of Brin's cylinders.

Capacity of cylinder in cubic feet.	Diameter in inches.	Length. ft.	Length. in.	PRESSURE IN POUNDS. 1,800	1,700	1,600	1,500	1,400	1,300	1,200	1,100	1,000	900	800	700	600	500	400	300	200	100	50
				CUBIC FEET OF GAS.																		
3	3	0	7	3	2¾	2½	2½	2¼	2	2	1¾	1½	1½	1¼	1	1	¾	½	½	¼	—	—
5	3½	0	11	5	4½	4¼	4	3¾	3½	3¼	3	2¾	2½	2	1¾	1½	1¼	1	¾	½	¼	—
10	4	1	4	10	9¼	8¾	8¼	7¾	7¼	6¾	6	5½	5	4¼	3¾	3¼	2¾	2	1½	1	½	¼
12	4	1	7	12	11¼	10½	10	9¼	8½	8	7¼	6½	6	5¼	4½	4	3¼	2½	2	1¼	½	¼
20	4	2	6	20	18¾	17¾	16½	15½	14¼	13¼	12	11	10	8¾	7¾	6½	5½	4¼	3¼	2	1	½
40	5⅜		6	40	37¾	35½	33¼	31	28¾	26½	24¼	22	20	17¾	15½	13¼	11	8¾	6½	24¼	2	1
80	5⅜	5	0	80	75½	71	66½	62	57¾	53	48¾	44¼	40	35½	31	26½	22	17¾	13¼	8¾	4¼	2
100	5⅜	6	6	100	94¼	88¾	83¼	77¾	72	66½	61	55½	50	44¼	38¾	33¼	27¾	22	16½	11	5½	2½
125	5⅜	8	0	125	118	111	104	97	90¼	83¼	76¼	69¼	62½	55½	48½	41½	34½	27½	20¾	13¾	6¾	3¼
225	5⅜	14	0	225	212½	200	187½	175	162½	150	137½	125	112½	100	87½	75	62½	50	37½	25	12½	6¼

Altered from the "Indispensable Handbook to the Optical Lantern."

CHAPTER XI.

THE ELECTRIC LIGHT.

If the oil lantern be the most convenient form of light for projection on a small scale and the limelight for general purposes, the electric light is undoubtedly the ideal illuminant for the lanternist, and at the same time the most theoretically perfect in action, since it condenses the most brilliant light possible in the smallest area, thus approaching more closely than any other radiant to the ideal "point."

At the same time, it must be borne in mind that it is of comparatively limited application, since it is only where the conditions admit of the supply being laid on for general illuminating purposes that it can be applied with any advantage to the lantern. The idea of generating the supply for the special purpose by means of the battery, or even of accumulators, must be abandoned at the outset, both on the score of convenience and portability and also of economy, for under such circumstances the trouble and expense involved in its use would place it quite beyond reach either for home use or for travelling purposes. But a redeeming feature is to be found in the fact that it is precisely under the conditions where it proves of greater value that it is most likely to be available, namely, for projection on a large scale in public halls. Here, where the advantage of the powerful illuminant is most to be appreciated, the electric installation is the more likely to be found, for which reason the arc light must certainly be considered as one of the most valuable illuminants at the command of the lecturer. In the remarks that follow, it is obviously impossible to do more than very briefly touch upon the theory of electric lighting, and it is, therefore, assumed that the would-be operator either already possesses a knowledge of electrical science, or will, at least, post himself up to a sufficient extent for the purpose.

Of the various forms of lamp available, the incandescent or "glow" lamp may be dismissed as useful only for small discs,

under which conditions, when it happens to be available, it will prove a convenient and cleanly source of light. But as usually made for ordinary lighting purposes the area of incandescence is far too large in proportion to its illuminating value to be of much use. However, a special form of lamp is constructed by the Swan-Edison Company for projection purposes. In this the filament takes the form of a helical spring, or coil, which is presented endways towards the optical system, by which device a comparatively small area of more intense light offers itself to the condenser.

But for all really practical purposes we must fall back upon the arc light, which can be obtained, under suitable conditions, of a practically unlimited candle-power and of a whiteness and brilliancy unapproached by even the best lime light. In this form of light the illumination proceeds partly from the so-called arc itself, which is formed by a stream of incandescent particles from one of the carbon points to the other, but chiefly from the carbons themselves, which are rendered incandescent under the intense heat of the current.

Here it is necessary to call attention to the different forms of arc light, one of which is formed by a continuous, the other by an alternating current of electricity. In the first instance, the current proceeds continuously in the same direction; in the other it reverses or "alternates" its direction a very great number of times in a second. The different kinds of current exert a most important influence, not only on the character of the light but also on the condition of using it, as we shall endeavour to show. In the first place, as has been already stated, the arc is formed by a stream or current of incandescent particles of carbon passing from one point to the other, and it will be readily understood that under such circumstances—when the electric current is a continuous one in the same direction—the stream of particles must partake of a similar character, with the result that, though both carbons are consumed or burnt to some extent, this does not occur equally; the positive carbon, or that from which the current flows, suffers consumption twice as rapidly as the negative one, towards which the incandescent particles are borne by the current, and which is thus partly built up again. In the case of the alternating current the consumption of the two carbons goes on equally and symmetrically, since the

process is one of a give-and-take nature, and each point suffers precisely similar treatment. It might be assumed that the latter was the better form of light—though actually the reverse is the case in practice, for reasons that will be shown.

If after the light has been burning for some time under the influence of a continuous current the carbon points be allowed to cool, so as to admit of minute examination, it will be noticed that the negative carbon—usually the lower one—has had a small rounded knob formed on its point, while the upper—or positive—has been burnt into a small hollow or "crater," as it is technically called; and it is from this crater that practically the whole of the useful light proceeds, as will be seen on examining the arc through a smoked or coloured glass while the current is passing. A similar examination of the effect of the alternating current will demonstrate the fact that each of the carbons is equally hollowed, but very slightly, forming two imperfect craters, which, besides giving an inferior light, throw it in a direction in which it has no practical value, as will be shown later on in describing the lamp. In addition to this, the arc itself assumes a violet or reddish colouration, often varying rapidly with changes in the strength of the current, and which detracts considerably from the quality of the illumination. For projection purposes, too, the alternating current has a special disadvantage, since it throws a shadow on the centre of the screen, caused partly by this coloured flame and also by the carbons themselves intervening to cut off a portion of the light emanating from the craters. The projected central shadow is, in fact, a shadow of the carbon points.

Such is the *rationale* of the formation of the electric arc. We will now proceed to describe the apparatus or lamp by which it is produced. This consists, in its simplest form, of a standard or upright carrying two holders or sockets, in which the carbons are fixed so as to present their points to one another at a short distance apart. But beyond this, some means must be provided by which the distance can be varied so as not only to permit the carbons being adjusted at the proper distance to give the best light, but also to allow that distance to be maintained as the carbons are consumed. Moreover, in order to start the light, it is necessary that the carbon points actually touch one another for an instant, since a current of the strength usually employed is incapable

of leaping over any but the most infinitesimal gap until that space is filled with heated particles of carbon, or carbon vapour. Thus it becomes necessary to "strike the arc," as the operation of momentarily bringing the carbons together is called, and then recede them to the necessary distance. If this be insufficient, light is wasted both by not getting the best result possible out of the current and also by a portion of it being intercepted by the negative carbon; if the proper distance be exceeded the arc flares up and becomes coloured, thus losing much of its efficiency, besides spluttering and emitting an unpleasant humming noise.

Thus, it will be seen that there is room for the exercise of a good deal of ingenuity in arranging for the due performance of these adjustments, and a very great number of lamps have been devised for the purpose. These are of two kinds—"automatic" or "hand-feed"—in the former of which the distance is adjusted or regulated automatically by the current itself, in the latter by hand with suitably arranged rackwork. For ordinary illuminating purposes the first description is practically a necessity, and the lamp or "regulator" is, consequently, an elaborate, delicate, and frequently costly piece of apparatus; but for projection purposes, although several simple forms of automatic lamp are in use, many operators prefer to rely upon hand adjustment, which fulfils every requirement and necessitates a less elaborate instrument. In the Davenport-Steward Universal Arc Lamp (shown in Fig. 41), we have an instrument of the latter class, consisting of a firm base and standard carrying the carbon holders, which are adjustable by means of separate milled pinions. The frame carrying the holders is hinged to the upper portion of the standard, and this forms an important feature in all lamps, since it permits the carbons to be inclined at such an angle that the light proceeding from the crater when using a continuous current is reflected or thrown right into the condenser. The diagram shows the lamp adjusted for a continuous current; but, in the case of an alternating current, the carbons would occupy an upright or vertical position. From what has previously been said in connection with other forms of illumination, it will be remembered that the accurate centring of the light is a matter of the utmost importance, and this is no less the case with the electric arc. The standard is provided with a rack and pinion for adjusting the height, and with a rotary

fitting and clamp at top for lateral centring. The hinge for inclining the carbon is fixed in any desired position by means of a clamp, and the further adjustment of the position of the crater is quickly performed by means of the rackwork adjustment shown. Another milled head, fitted with pinions of different sizes, separates

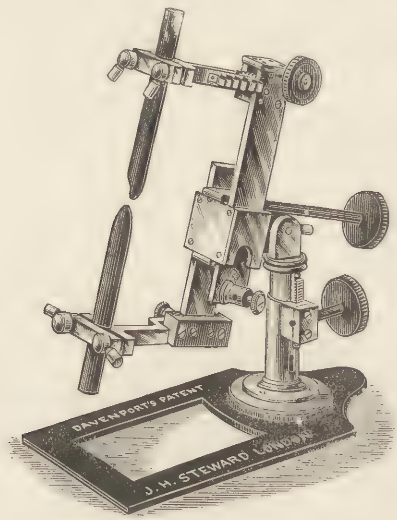


FIG. 41.—DAVENPORT-STEWARD UNIVERSAL ARC LAMP.

or brings together the carbons as may be necessary, and provides the necessary adjustment to make good the consumption. A slight turn every two or three minutes effects this purpose.

The Ross-Hepworth Arc Lamp (Fig. 42), another form of hand-feed instrument, possesses special features. The pinion which regulates the adjustment of the carbon is connected with a tangent wheel and worm wheel, which impart a slow feeding motion in contrary directions to the carbons. It is further ingeniously adapted to perform another function—namely, the quick striking of the arc; for, if the feeding handle be simply pushed in, the worm wheel acts the part of a rack, and imparts a rapid rotary motion to the pinion, thus bringing the carbons quickly together. A spiral spring on the feeding handle serves to instantly return them to their original position. This permits the carbons to be set at the proper distance before commencing an exhibition, and

the arc can be quickly struck and the light set going without any of the usual trouble. The lamp is also fitted with a vertical rack and pinion, by which the point of light can be brought to

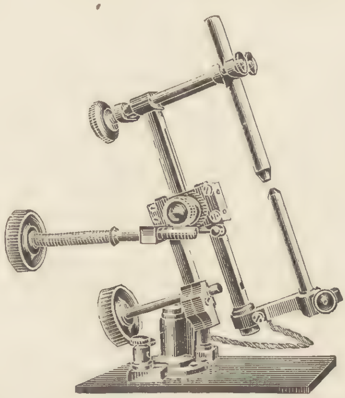


FIG. 42.—ROSS-HEPWORTH ARC LAMP.

the optical centre if any irregularity in the rate of burning should displace it.

The newest, and, in all respects, one of the most convenient lamps on the hand-feed principle, is the New Model Projection Arc Lamp of Messrs. Ross, Limited, shown in Fig. 43. The

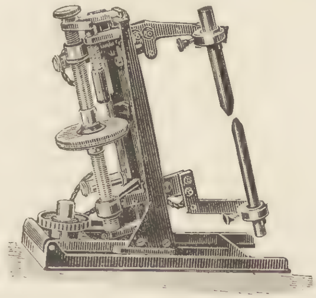


FIG. 43.—NEW MODEL PROJECTION ARC LAMP.

body in this is set at a fixed angle with the base, and serves the dual purpose of supporting the working parts and of acting as a screen for the back of the lantern. The large milled head in the centre supplies the slow motion for feeding the carbons as they

consume, and that in the base controls the lateral adjustment, the vertical being effected by the long thin one shown towards the upper part. The arc is struck by means of the lever placed just above the bottom holder.

If an automatic feed lamp be preferred, the pattern manufactured by Messrs. Newton & Co.—Major Holden's patent—can

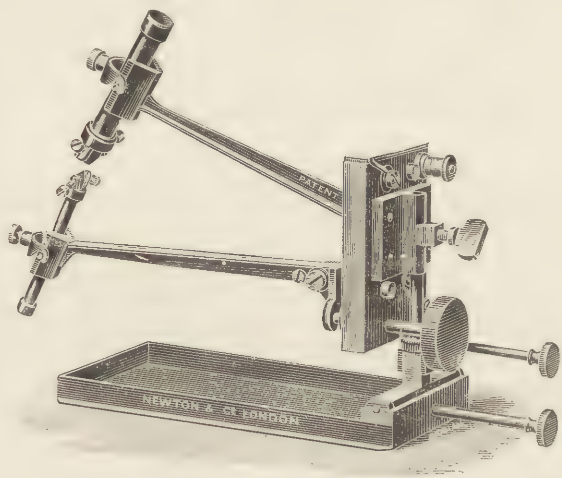


FIG. 44.—HOLDEN AUTOMATIC FEED LAMP.

be recommended. It is extremely simple in construction, and is made to clamp on to the rod of the tray of an ordinary lime-light lantern. It is essential, however, with this form of lamp, that the current be steady and not liable to constant fluctuations; otherwise, and for alternating currents, it is preferable to use a hand-feed lamp, which can be better regulated to the constantly changing current.

Very efficient lamps, both automatic and hand feed, are made by Borland, of Leeds, under the name of the "Scissors" Arc Lamp.

It is necessary now to say a few words on the subject of the carbons themselves. These should be of the very best quality obtainable, as the cheaper kinds, without effecting any very great saving in first cost, give rise to a vast amount of trouble and dissatisfaction. The size and hardness of the carbons also should

be selected with due consideration of the strength of the current, the stronger the current the thicker and harder the carbon. When using the continuous current, owing to the unequal consumption of the two carbons, it is usual to employ them of different sizes, the lower or negative being the smaller. For a current of ten ampères, which gives a light about equivalent to a good mixed limelight jet, the sizes generally employed are seven millimetres for the lower, and ten millimetres for the upper; while for currents up to fifteen ampères the sizes may be increased to ten and thirteen millimetres. For alternating currents both carbons should be the same size, and the larger dimensions given above should be chosen.

With even the best carbons some trouble often arises through the irregular formation of the crater, owing to slight variations in the homogeneity of the material. To obviate this difficulty the upper carbon is frequently "cored," that is, made with a central core of softer carbon in order to encourage the formation of the crater in a central position. With the alternating current, as already mentioned, the light is always less satisfactory, by reason of imperfect formation of the craters and their position. Here, again, an improvement is effected by the use of eccentrically-cored carbon, in which the core is placed at one side of the centre. These form the subject of a recent patent granted to Mr. T. C. Hepworth, and are intended to encourage the consumption of the carbon in the proper place. If two of these pencils be placed in the holders with their soft cores to the front, the carbon in those portions will be consumed more rapidly, and the tendency will be not only to keep the light on the front of the pencils, but also to wear them away in such a manner that they do not interfere with the proper direction of the light. It is claimed that by the use of this form of carbon not only is the light produced by the alternating current doubled in value, but the violet band and shadow already referred to are done away with.

It only now remains to say that in order to adapt the supply to the amount of current required to produce a light of given strength a "variable resistance," or rheostat, will be required. In order to render the function of this intelligible it will be necessary to refer briefly to the methods of measuring adopted in connection with the electric current. The units adopted for this purpose are the volt, the ampère, and the ohm. The volt is the unit of electro-

motive force, or "pressure" of current supplied; the ampère is the unit of quantity of current employed; while the ohm is the unit of "resistance," or of work done. A volt is the amount of power that will pass a current of one ampère through a resistance of one ohm; 100 volts will send one ampère through 100 ohms or 10 ampères through 10 ohms. The usual voltage supplied is 100, and, as has been mentioned, the strength of current employed from 10 to 15 ampères. The resistance offered by an arc employing 10 ampères of current is about 3 ohms, so that in using 100 volts it is necessary to provide an additional resistance of 7 ohms, otherwise something will have to give way, and that something will be the conducting wires, which will be overheated to fusion.

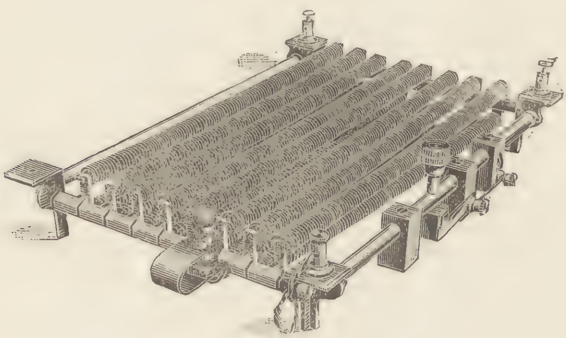


FIG. 45.—ROSS'S RHEOSTAT.

This is where the "resistance," or rheostat, comes in. It consists of a frame carrying a quantity of coiled and insulated wire of sufficient hardness and infusibility to withstand the great heat generated—for the effect produced is similar to, though not permitted to reach the same degree, as in the filament of an incandescent lamp—and this is interposed somewhere in the circuit—*i.e.*, between the main wires and the carbons to absorb the surplus voltage. Figs. 45 and 46 represent two forms of "resistance" supplied by Messrs. Ross, Ltd., and Mr. J. H. Steward, and with the description we have given will sufficiently explain themselves. By altering the position of the connection with the rheostat, more or less of the wire can be brought into circuit, and the resistance varied instantly, when it is desired to lower or increase the power of the light.

In order to prevent accident from excess of current, it is usual to provide safety fuses, placed somewhere in the circuit and in as accessible a position as possible. These consist of short lengths of fusible wire, usually of tin of such thickness as to melt under any

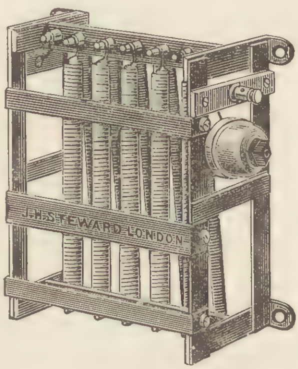


FIG. 46.—STEWARD'S RHEOSTAT.

abnormal increase of energy, and thus cut off the current altogether and prevent further damage. The operator should be provided with a supply of suitable wire with which to make his connection, and so ensure safety.

It is tolerably certain that in the future the application of electric lighting to the lantern will undergo still greater developments than during the period that has elapsed since the earlier editions of this work appeared.

CHAPTER XII.

SCREENS AND FRAMES.

We have now to deal with a part of the system which the practical worker will find much more important than the inexperienced or mere theorist might imagine. A good "screen" or surface for receiving the image makes a great difference in the results, a bad screen may easily absorb or disperse uselessly 25 per cent. of the illumination.

A screen ought to be opaque, white, and matt, not translucent (except for certain almost obsolete arrangements), nor "shiny," nor yellow. At one time it was not uncommon, and even yet it may at times be necessary to use a translucent screen; in this case a very thin linen screen is used and is almost of necessity kept damp. But such a system is comparatively poor, and ought to be resorted to only when the other is not available.

If the same room is always to be used for the lantern work, portability of the screen is of no moment, and in such a case we can easily attain to a perfect receiving surface. A smooth, plastered wall is as good a surface as can be got. A stout fabric such as canvas, may be faced with paper, or it may be heavily coated with sized white pigment. In mixing the pigment a little blue should be added to kill the yellowness of the whitening. If the screen is required to roll up like a school map, some care is required in mixing the pigment to make it in such a way that there shall be no cracking when the screen is rolled up. This is a matter for experiment; if when the screen is dry after painting the white can be rubbed off easily by the finger, more glue is required; if the surface is at all glossy, there is probably too much glue. For painting, the canvas is stretched on a frame, laid face upwards, and the pigment laid on as evenly and as rapidly as possible.

Mr. Hepworth's directions are somewhat as follow: Tack good unbleached calico to a frame so that the seams, if any, run horizontally. Secure first the four corners with tacks to frame, then nailing one side at a time to the frame. Give the sheet a good

coat of the best size, melted by heat with its own weight of water. The sized sheet is allowed to dry, and thereafter is painted with whitening and melted size. The whitening, water, and size mixture should, when first made, have the "consistency of cream"; when cool it will be like a thin jelly. Mr. Hepworth then places the frame upright, and proceeds to work the brush charged with the paint up and down and sideways, so as to avoid leaving any lines upon the surface.

We are informed that the best of all "pigments" to mix with the size is zinc white; we have not ourselves tried this, but believe that the claim for it is well founded. Mr. Bull, of Great Queen Street, London, makes very fine screens with this pigment.

Facing a screen with paper requires, we fancy, an experienced hand, the paper cannot be got in large enough sheets and the laying down of the edges where the sheets join is no easy matter. Of course, if we only require a small screen, as for exhibiting to small audiences, single sheets of paper may be produced of sufficient size, and only require at the most to be attached to suitable supports.

Up to (say) 10 feet square the advantages of a "faced" or sized screen are so great as to quite balance the awkwardness of a 10 feet roller for transportation from place to place. Up to 10 feet we therefore recommend such a screen, even for travelling. But beyond 10 feet the length of roller required becomes very inconvenient, and we have to look for a screen material that may be folded up, and a method of so stretching it when in use as to obviate the creases naturally following the folding. To meet these *desiderata*, we use rather thick linen or cotton screens, and we stretch them on "screen-frames." Cotton seems to be less used than linen, so we shall confine our remarks to the latter. We believe that pieces of suitable linen can be got up to 10 feet square, but, as we have said, we should prefer a faced or sized screen of that size. If we have to join pieces of linen for a screen, say, of 18 feet, we must avoid having our seam or joint near the centre. In such a case it would be better to have a complete square of 10 feet in the centre, with four feet tacked on all round, rather than simply to make an irregular patch-work. As these screens are sold ready made in any usual size, we need not do more than point out that the seams should be as far from the centre as possible, and that they should run perpendicularly rather than horizontally on the

picture. If a seam falls coincident with the horizon of a picture the effect is apt to be very unpleasant.

In order to improve the surface and give a better lighted picture, the screen has been prepared with a plain metallic surface, or coated with a metal foil, but the objection to this style of screen is stated to have been that the projected image is only properly seen from certain directions. To obviate this objection, Messrs. Lewis Wright and John Anderton some two years ago took out a patent for a metal-faced screen, in which the metallic surface instead of being smooth has a finely-patterned rough surface. The sheet is coated with "silver or other metal," or metallic powder, and the surface is "covered over with fine grooves or striations arranged perpendicularly or otherwise, or indentations, corrugations, or other irregularities of any kind" . . . "for the purpose when in use of causing the rays of light to be scattered laterally, and thus increasing the lateral reflection of the light and thereby causing the projected image or images to be seen with equal brightness from any point of view." We have heard the "silver screen" well spoken of, and no doubt for small discs it may be an improvement.

There is no great variety in the designs of screen-frames, or "elevators," as they are sometimes called. A screen-frame should be as light as possible consistent with strength sufficient to keep a screen quite taut; it should take down into as many short pieces as is consistent with strength; it should be capable of being rapidly put together and taken down; it should afford facility for elevating the screen; it should stand by itself, and it should be capable of being tilted slightly without chance of falling down. When the frame is tilted is the time when strength is required, for a tilted screen will "sag" forward under such conditions unless the frame be strong enough to counteract the tendency. We have seen it stated in print that the advantage of being able to tilt the screen is more theoretical than practical, but we must dissent from this statement; a tilt is frequently a *conditio sine quâ non* of real success. In our own experience the screen is tilted nine times out of ten.

We figure an "elevator" such as we find perfect for our purposes up to a twenty-foot screen. The poles are two inches in diameter, the length about five feet each, the junctions are strong brass ferrules, the corners are solid metal. The lengths are so

made that we need not use all of them at a time unless we wish, so that we may choose our size of screen up to twenty feet, increasing or diminishing by about four feet at a time, or two feet if the lengths are made on purpose for such a choice of size. (Fig. 47.)

At the foot will be seen strong cross-pieces, which form a base, and with the addition of the four straps attached to the lower part of the frame, help to prevent the screen and frame from toppling over if tilted. The tilt is arranged and maintained by shortening and lengthening the front and rear straps respectively, and the frame works freely in the holes made for the purpose in the base cross-pieces, so that any tilt can be obtained in an instant. It would be better to attach the guys at a point higher on the uprights.

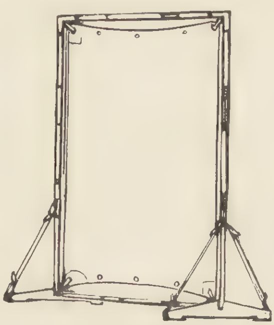


FIG. 47.—"ELEVATOR."

There are various methods of mounting a screen on its frame in a hall preparatory to a lecture. Perhaps the most convenient way is to put the poles forming the top of the frame together, joining to these by the solid metal corners the first lengths of poles below the top bar; to tie the screen by its tapes to these lengths, and then to join on the next lower poles, tying the screen to these in their turn till the whole is erected. By means of the bottom tapes, and those within reach with or without the ladder, the whole fabric is finally made taut. With a large screen we always fix guys to the metal corners at the top, and fix the guys to anything that comes handy, as a rafter or staple driven in by ourselves if the authorities permit. We have a twenty-foot frame of four-inch poles which always require guying, and in any case a couple of guys when the sheet is tilted ease the strain on the pole ferrules greatly. A very good adjunct to a screen is a pair of tasteful

curtains, which may be simply hung on the top of the frame and drawn aside by simple means as the lecture is about to begin.

If an opaque or "faced" screen is to be used, nothing is required but two side arrangements to support the ends of the roller on which the screen is wound.

CHAPTER XIII.

SUPPORTS. SLIDE CARRIERS. READING LAMPS. SIGNALS.

WE naturally require some kind of stand upon which to place the lantern, and the larger and heavier the latter the stronger must be the support. Sometimes stands are made with sliding legs, so that the lantern may be reared up very high, but we see no use for any such height, in fact, the highest lantern, if we are using a double or triple, should be as little above the level of our eyes as possible. Even if we are with the lanterns in the middle of our audience, the lowest lantern need only clear the head of the sitter immediately in front, and if tilting the screen is inconvenient, mounting a ladder to see into the lantern is ten times worse.

But the kind of stand used in a photographic studio for carte and cabinet cameras answers very well. Such a stand, however, can hardly be called very portable, and if the box which carries the lantern when travelling be placed on an ordinary table, more especially if a canting table be added, there will be no necessity for further *impedimenta*.

"Carriers" may be described as guides by means of which slides are passed through the part of the lantern in front of the condenser. It is important that slides should pass smoothly into and out of their position in the light-way; each one must find the central position at once, without any fumbling on the part of the operator, and when more than one lantern is being used, as for dissolving effects, it is essential to success that the slides should "register"—*i.e.*, should have coincident discs on the screen. For multiple lanterns a certain amount of intricacy in the carriers may be necessary, but for a single lantern the simpler it is the better. After using nearly every carrier known in the market, the writer goes back to the simplest of all, the old "Chadwick," or, failing that, one very nearly as simple, made by the late Mr. Place, of Birmingham.

Both these carriers are so made as to take and to centre at once any ordinary size of slide. The "Chadwick" should be made of thoroughly-seasoned, well-smoothed wood. The "steps" are made to suit the three different lengths of slides in vogue at one time; one slide pushes the one in front through, one or other "step" being used as a guide for the hand that pushes the slide. In Mr. Place's carrier the slide is let in from above, a push on the metal projection turned up in the apparatus at once centres the slide, and on further pushing, the frame carrying the two slides slips along, and so one slide is put away as another comes on. For dissolving lanterns "Beard's self-centring" is as good as any.

Some people dislike an interval of darkness, however short, between the pictures; some dislike a period of brightness on the screen. Many efforts have been made, and appliances contrived, to simulate dissolving effects with a single lantern. So far as we have seen, these contrivances are of no value; if any such attempt must be made, the operator may hold in front of the lens while the slides are being changed a piece of very fine-ground glass. For ourselves, we see no objection, but rather an advantage, in the short space of semi-darkness produced by the use of a Chadwick or Place carrier. A blaze of light on a white screen for a short time is, in our opinion, most objectionable; it tries the eyes and spoils the first effect of the pictures following.

We can speak highly of the "Eclipse" carrier of Mr. Beard; it is very ingenious in construction, and the effect on the screen is perhaps more nearly that of dissolving than is produced by any other carrier. Mr. Beard has lately made a very simple carrier on the push-through principle; the grooves are so bevelled that the slides always come to the same plane, they are all, therefore, at one focal plane and cannot be pushed one in front of another.

There are many kinds of reading lamps intended for use by the person on the platform. Of course, the object is to throw light on the book or paper without illuminating the screen. By highly-ingenious contrivances of this kind we have never been able to read comfortably, and we have repeatedly been left in darkness during the performance. Since first we used a "candle shade," kept at most good ironmongers, we have never used any other reading lamp.

A signal between lecturer and lanternist is generally requisite; an electric communication acting on a muffled bell is the neatest device; failing that, we know nothing better than a gentle tap with a knife on a glass of water, or the click of a castanet *à la* Muybridge.

All indiarubber tubing used for lantern purposes should be of the very best quality, and a bore as large as may be consistent with fitting the taps and jet-tubes. The larger the bore the less the friction of the gases in the tubes, and diminution of friction helps greatly towards brilliance and steadiness of light. Tubes should not be unnecessarily long; first, because redundant tubing means extra friction; secondly, because spare coils of tubing are inconvenient and apt to be trodden on and get in the way; lastly, rubber tubing can hardly be too thick in the walls; very thick-walled tubing is dear to buy, but cheap to use. Rubber tubes should be pushed far up on the metal tubes to which they are "sprung," and it is always a good precaution to tie on the rubber tubes to the metal ones.

Various kinds of boxes are made to hold lantern slides; we like a box for each set of slides—each lecture, for instance; and the box should have no grooves, but may have a spring arrangement to push the slides up against each other in the box.

Slides frequently "sweat" in the lantern owing to moisture being imprisoned between the glasses. If the slides can be thoroughly heated before the lecture this very unpleasant defect will be obviated. If slide-boxes are made of metal, say tin, they can be put in a gentle oven, or on a hob, before they are put into the lantern. We have even seen a metal box containing slides heated by means of a spirit-lamp.

CHAPTER XIV.

LANTERNS AND ARRANGEMENTS FOR EXPERIMENTS.

THERE are many scientific experiments for full comprehension of which we depend chiefly upon our eyesight, and it is easy to understand that if we can utilise the lantern for showing on a large scale the image of an experiment being made on a small scale, we have found a further use for the lantern. As a matter of fact, many chemical, magnetic, optical, and other experiments can very easily be shown to a large audience, though conducted on a small scale, and we may add to this the fact that it is possible to add to an ordinary optical lantern a projection microscope, polarising and spectroscopic apparatus, and various other optical appliances.

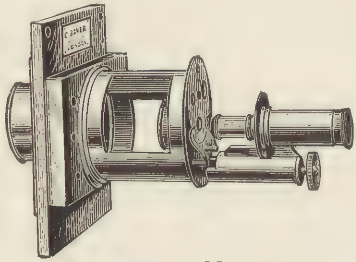


FIG. 48.—LANTERN MICROSCOPE.

It is long since attempts were first made to project images of microscopic objects by means of a microscopical objective and suitable condensing lenses. The animal and vegetable contents of a drop of water have many times been projected with high magnification on a screen; fleas and other insects have many a time figured on ten-feet discs; but lately considerable advance has been made in this line, and images of very minute structures may now be projected by even immersion objectives.

Figure 48 shows a simple arrangement, worked out by Dr. E. C. Bousfield and the writer, for the projection, with ordinary

apparatus of the microscopist, of microscopic images when very high magnification is not required. An ordinary "bull's-eye" takes the place of the lantern condenser; in front of this is a trough which holds water or alum solution; there is the ordinary fitting for a substage condenser and provision for a certain amount of focussing of the condenser. The stage has a round plate with apertures of various areas and clips for holding the objects. The

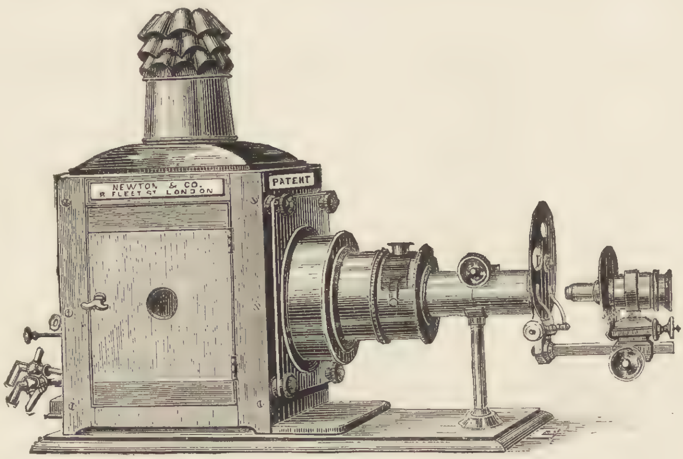


Fig. 49.—Wright and Newton's Combined Lantern and Microscope.

microscope tube in front has a coarse and a fine adjustment, and we find the whole arrangement works very well with objectives up to ⅔ and ½ inch. The lens by Zeiss, of Jena, known as the "*aa*," which has a focal length of about one inch, works very well and without any substage condenser; but with a ½ or $\frac{4}{10}$ glass we find it better to use a low-angle condenser. So far as this arrangement pretends to go it gives results as good as any simple arrangement in the market, and its price is small. Mr. Baker, of Holborn, made the one here figured. The entire arrangement fits to the front of an ordinary lantern. A higher class article is the outcome of Mr. Lewis Wright's experiment and ingenuity. Here also (Fig. 49) we have power of using and adjusting a microscope condenser, and there is a "fine adjustment" for the micro-objective, as well as an alum cell to prevent the slide being damaged by heat. Another excellent instrument for

the same purpose was worked out by Mr. E. M. Nelson, and is made by Mr. Baker.

A special condenser of the triple type is recommended for this projection arrangement.

In like manner, a polarising apparatus may be attached to the front of the lantern. The apparatus (Fig. 50) we have seen used with great success.

Spectroscopic experiments may be demonstrated by means of an ordinary lantern with a slit-diaphragm attached to the front, prisms and collimator being placed on suitable stands between lantern and screen. With an electric lamp and a primary battery, and an apparatus designed by Mr. John Browning, the writer has carried out many interesting experiments on the spectra of metallic

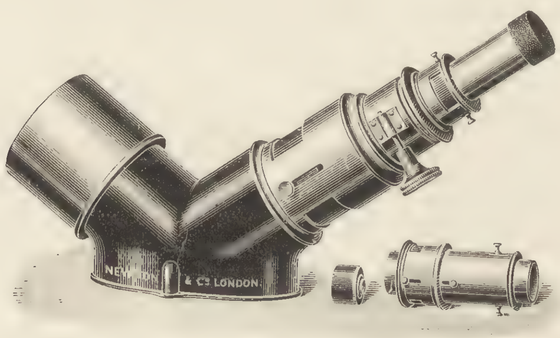


FIG. 50.—POLARISING APPARATUS.

and other substances. Demonstrations on such lines take a firm grasp of the attention and interest of any audience.

For chemical experiments, and, indeed, for many others, an "open stage" is almost a necessity. Fig. 51 shows a lantern well adapted for such work.

A so-called tank or cell may be placed in the open stage, and in this tank chemical reactions may be made to take place, the action being finely displayed on the screen. The same may be said of magnetic, electric, and very many optical experiments. If a sheet of orange or yellow glass be placed between the condenser and the tank, a photographic image may easily be developed, *coram populo*, care being taken to use a very "slow" plate, such as a chloride plate used for lantern slides. For these and other experiments with liquid in the cell, a pipette

should be used to drop in the reagents that determine the action, the cell having been previously nearly filled with one of the liquids. A very interesting series of experiments, capable of being well shown by the lantern, will be found in the contributions of the late W. B. Woodbury, to the *English Mechanic* some years ago, and subsequently published in separate form under the title of "Science at Home," by the Sciopticon Company.

Of late years considerable attention has been given, by opticians, to lanterns of the highest class, adapted more particularly to scien-

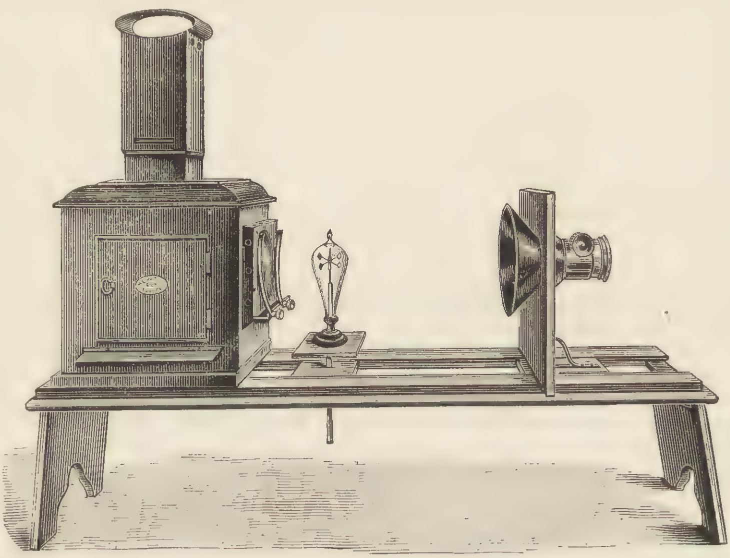


FIG. 51.—OPEN-STAGE LANTERN.

tific purposes and to experimental demonstrations. In these provision is made for the introduction, between the condenser and the objective, in the place of the ordinary slide carrier, of various instruments and pieces of apparatus by means of which a great variety of experiments may be demonstrated to large audiences by projection on the screen. Arrangements are also made by which special forms of microscope, polariscope, spectroscope, and other instruments can be readily attached, and the various phenomena exhibited to a crowded room, instead of being confined to a limited number of observers. In Fig. 52 is shown one of the earlier, but

well-tried instruments of this class, constructed by Messrs. Newton and Co. It is designed for use with limelight only, and in the lower lantern such pieces of apparatus as the radiometer, the electroscope, galvanometer, or Leyden jar may be introduced between the condenser and projecting lens. The upper lantern at the same time can be used for the projection of slides in illustration of the experiments demonstrated by means of the lower one; or, when placed in the position shown, serves the various purposes of vertical projection. This is useful, or indeed,

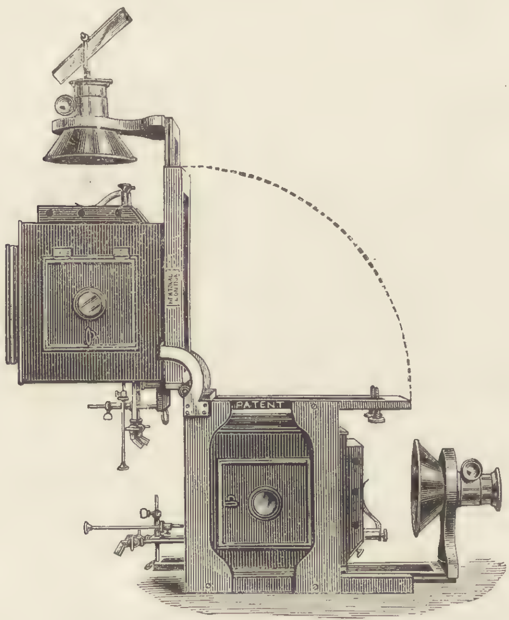


FIG. 52.—NEWTON'S SCIENTISTS' BI-UNIAL LANTERN.

essential, in a variety of physical experiments, such, for instance, as the crystallisation of salts, or it will enable sketches to be made and exhibited on the screen while being drawn. In the ordinary vertical arrangement the elements of the condenser are separated, two reflecting mirrors being used, one of which is placed between the separated elements. But in this instrument there is only one reflecting surface, for which reason greater brilliancy is claimed; and as the condenser of the upper lantern is not interfered with,

it is instantly available for either purpose by simply turning it on its hinges.

Quite recently, in conjunction with Mr. Ives, Messrs. Newton have patented an extremely handy and portable instrument, which they call the Universal Science Lantern, and which is adapted for use either with limelight or the electric arc. This is shown in Fig. 53, and is fitted, as will be seen, with a triple front, any one of the objectives of which can be brought into action in a couple of seconds. The first objective consists of an ordinary 6-in. achromatic lens for the exhibition of slides or diagrams; the second is

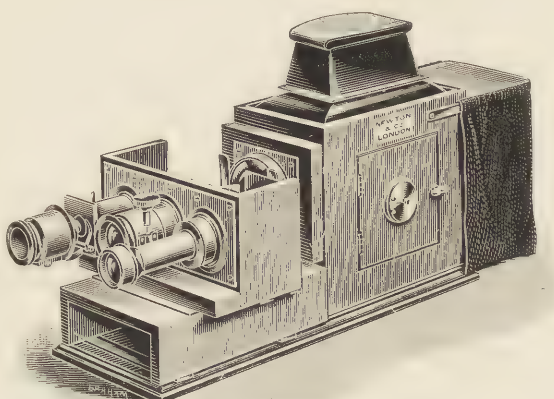


Fig. 53.—The "Newtonian" Universal Science Lantern.

a microscopic attachment fitted with substage condenser and various powers; the third consists of a direct vision spectroscope with achromatic focussing lens, and projects a brilliant spectrum without the inconvenience attending the use of a single prism. A second prism is provided for the comparison of different spectra. These parts may be removed, and a vertical attachment, polariscope, or other apparatus attached in a few seconds. The apparatus complete packs into a very small space, and is well adapted for general lecture purposes.

Messrs. Ross & Co.'s New Patent Science Lantern is shown in Fig. 54 as used in ordinary projection work, and in Fig. 55 when applied to vertical projection. It is double-fronted, each front being fitted with a triple condenser of improved form. One

front takes ordinary slides, diagrams, or tanks for precipitation experiments; the other is for parallel beam work and light experiments generally, and is also arranged to take microscopic attachment, polariscope, or any of the additions usually employed. By raising the handle shown in front of the diagram (Fig. 54),

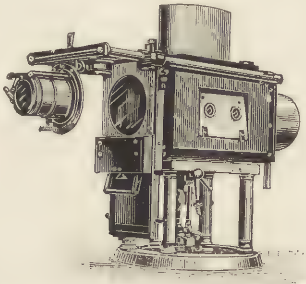


FIG. 54.—ROSS' NEW PATENT SCIENCE LANTERN (ORDINARY PROJECTION).

the stage can be raised into a horizontal position for use in vertical work. By means of the handle projecting downwards from the large tube of the opposite front, the whole instrument can be swung round, the light remaining stationary, so as to bring either front into a central position for use. The instrument as shown

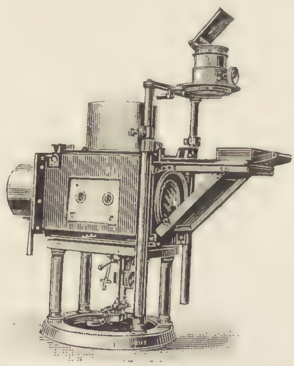


FIG. 55.—NEW PATENT SCIENCE LANTERN (VERTICAL PROJECTION).

is intended for use with limelight only, but a larger form is constructed for use with the electric arc. This forms a most complete and efficient apparatus for the demonstration of every description of physical experiment.

CHAPTER XV.

ANIMATED PHOTOGRAPHY AND PROJECTION.

Obviously a work like the present, which is intended to embrace every phase of lantern projection, would be incomplete without some reference, however brief, to the latest and most sensational development of the science—a branch that only a few years back, however much it may have stimulated the dreams of scientific enthusiasts, would have been impossible without the successive advances made in recent years in purely photographic processes. The gradual increase in the rapidity of gelatine emulsions, improvements in lenses, and, above all, the production of suitable flexible surfaces on which to support the pictures in such a manner as to render them easily applicable to the purpose in view, combined to bring the principle of animated photography within the scope of practice, and after that the mechanical arrangements were made with comparative ease. Although the apparatus necessary for taking and showing a long series of photographs in very rapid succession is necessarily somewhat complicated, it presents no serious difficulties to the expert mechanician, as is proved by the large number of different instruments now in use; and at the present day it is difficult to decide which to admire most—the ingenuity displayed in the construction of, or in finding names for, the different instruments. In the nomenclature advantage is taken of prefixes referring to "motion," "change," "life," or "animation," as in the "cinematograph" or "kinematograph," "kinetoscope," "mutograph," "biograph," "vitascope," and "animatograph," which may be selected as a few of the chief types that may be etymologically classed. Of others, it can be said, as of the "photo-rotoscope" and "motor-pictoroscope," that it is easier to imagine what they are than to trace their etymology; while again, with others such as the "Birtac," a dive behind the scenes, or a deep and intimate study of later nineteenth-century methods of nomenclature, serves to show the hopelessness of attaching any meaning to them at all. Where an attempt at etymology is made

at all, it would at least seem desirable to use the affixes "graph" and "scope," to describe the taking and projecting instruments respectively, and not to apply them indiscriminately, as now seems to be the fashion.

At the time of writing these lines, it would certainly be incorrect to say that the practice of animated photography has taken any great hold on amateurs, for whom this work is chiefly written, though, when the expense of the necessary additional apparatus and plant is not an obstacle, there is no reason why they should not venture into this department of projection—at least, on a small scale. But, up to the present time, the exhibition of animated photographs remains, beyond doubt, a showman's business, and a very popular and profitable one, while the production of the necessary "films" constitutes a new and lucrative profession in itself. Scarcely an event or ceremony of importance now takes place but is reproduced by at least one of the numerous "graphs" or "scopes," and, probably, the same evening is repeated in all its details before the audience of one or other of the variety theatres. In this manner public processions, funerals, weddings, launches, horse races, and even prize fights, can be placed on record for the benefit of future generations, and in the near future there is little doubt but the kinematograph will be largely used as an aid in astronomical observation. It is to be regretted that the first attempt to so utilise it in connection with last year's solar eclipse should have proved a failure from outside causes, but we may be certain the experiment will be repeated on the first opportunity.

Theoretically, the production and exhibition of living and moving photographs are simplicity itself, based as they are upon the principle of persistence of vision. The usual image formed upon the retina of the eye remains for a brief period—about one-tenth of a second—after the object causing the sensation is removed or hidden, and this explains why in winking the eyes we experience no break or interval in the visual sensation. If, then, a series of photographs be taken in very rapid succession of a moving object or scene, and these be subsequently projected on the screen with the same rapidity of succession and in such a manner that the different pictures fall in exactly the same position, and if means be adopted to cut off the light during the brief periods during which the pictures are changing, we have the effect of a continuously changing scene, the eye being unable, owing to the property

of persistence of the image, to recognise or take cognisance of the extremely brief periods of eclipse. Such is the simple theory, and the perfection or otherwise of its realisation depends, of course, upon the proper adjustment of the apparatus and its accuracy of working. What that accuracy really amounts to may be gauged, perhaps, by what follows.

It is customary in speaking of animated photographs, as at present shown, to refer to the crude phenomena exhibited half a century ago in such instruments, or toys, as the "praxinoscope," the "zoetrope," or "wheel of life"; but beyond the fact that these also were based upon the principle of persistence of vision, there exists very little similarity. These earlier attempts were simply made with more or less inaccurate drawings of successive phases of motion to depict the repetition of a single incident or act as—a smith striking an anvil, a boy jumping, a girl skipping, or the well-known example of our boyhood of the man swallowing rats. These were amusing enough in their way, and interesting from a scientific point of view, but constituted crude, jerky, and otherwise imperfect representations of the real incident. Even when some twenty years ago in many opticians' windows were to be seen at work zoetropes, in which the subjects were silhouette copies of Muybridge's series of trotting and galloping horses, the effect was scarcely any better, for, although the different phases of motion, being from photographs, were accurate in themselves, they were too few in number, and not accurately enough in register.

Much nearer perfection, though still leaving much to be desired, were the pictures from the original photographs projected on the screen by Muybridge himself for the benefit of such fashionable audiences as those of the Royal Institution, the Royal Academy, the Society of Arts, and, if we remember rightly, Eton College, besides the principal scientific and artistic bodies in Paris. These consisted, however, simply of a *procession of the same horse* or animal across the screen, and in the more complete series, as, for instance, a racehorse at full speed depicted in twenty-four phases, representing something less than half a second of time, the effect was very good.

Following the lead given by Muybridge, Professor Marey, of Paris, turned his attention to the analysis of the flight of birds by successive exposures made at extremely brief intervals. Muy-

bridge's exposures were mostly made with separate cameras placed at stated distances apart, the object being made to pass before them, and automatically make the exposures at fixed intervals. Obviously, under such circumstances, the relative positions of the moving object and the background or remainder of the subject changed in each successive picture, but as these pictures were nearly all taken against a perfectly white background, against which the object appeared as a black silhouette, the inconvenience that would otherwise arise from a constantly jumping and changing scene was not experienced. In some taken against a natural background the effect was not unlike what one might see from a terribly jolting railway train.

Professor Marey's apparatus, we believe, took somewhat the form of a gun, and was sighted in the same manner from the shoulder, the pictures being taken upon a rapidly revolving circular plate. They were exceedingly minute in size, and, speaking from recollection, were taken as many as fifty or sixty in a single second. These bore enlargement to considerable dimensions, and gave a surprisingly accurate idea of the original motions.

Lastly, as anterior to the era of modern animated photography, came the pictures by Anschutz of subjects similar to those usually selected for the old wheel of life, though many of them were much more elaborate. These, being produced upon accurate principles, and carefully registered, gave a much better representation of the subjects than had hitherto been seen.

This brings us to the early "nineties," but before this others had been busy upon the work of rendering moving scenes as distinguished simply from single objects in motion. In 1890 Mr. Friese Green exhibited and explained a camera devised for this purpose, but we do not remember that he showed any of the results produced. About this time, too, a patent was taken out by another Englishman—Mr. Wordsworth Donisthorpe—for a camera for similar purposes, but, so far as we are aware, he never went any further with it. In or about 1893 Edison took up the idea in America, and worked out an apparatus to which he gave the name of Kinetoscope. This, although inferior to the instruments that followed, may be taken as the first successful one of the kind.

In 1895, Messrs. Lumière, in France, introduced their cine-

matograph, which, after numerous improvements, remains one of the leading instruments. Early in 1896, Mr. Birt Acres gave the first public demonstration in this country of animated photography before the Royal Photographic Society, and later on photographed and exhibited at Marlborough House scenes at the wedding of Prince Charles of Denmark and Princess Maud of Wales. Since that period the growth in popularity of animated photographs, and of machines for their manufacture, has been enormous, and there is scarcely a music hall or variety theatre in any of our large towns but has an instrument permanently installed for the exhibition of current events and occurrences.

It would be quite impossible, even if we had closely examined all the instruments in use—which we have not—to give a detailed description of their working parts. We shall, therefore, content ourselves with giving a general description of the principles on which they are constructed, with diagrams of some of the leading ones. The complete outfit for the taking and exhibition of animated photographs may be divided into three parts—the camera, the printing machine, and the projecting machine. Some instruments combine all three; while others confine themselves to the task of taking only, or taking and printing; while others, again, only attempt the projection or exhibition.

Briefly, the method of procedure is as follows:—The pictures are taken upon long strips of flexible celluloid film, such strips being obtainable ready for exposure in various lengths according to the duration of the scene to be depicted. The standard width of film is 1 in., the individual pictures given by the Lumière machine being 25 by 20 millimetres, and the length of film required for a series of exposures lasting one minute, is about 60 ft. The films as sent out for use are perforated at the edges with holes to fit the sprocket or pin-wheels, by which they are passed through the apparatus, and which are necessary in order to ensure that the film travels at an absolutely uniform rate with the rest of the apparatus, or, in other words, that the pictures are accurately equi-distant. There are two different "gauges," to one or other of which most other instruments conform—namely, the Lumière and the Edison, the former having *one* hole to each picture, the latter four holes at either side. Greater lengths of film can, of course, be obtained if needful, or several of the one-minute lengths may be joined together, single films very often

reaching to several hundred feet in length, and carrying some thousands of exposures.

The unexposed film is placed in a receptacle provided for it inside the camera, and one end being disengaged, is passed over a series of rollers which take it in front of the lens, over the sprocket cylinder, and finally it is clamped to the receiving spool, upon which it is wound when exposed. With some forms of apparatus it is necessary to effect this connection in the dark room, while with others the daylight cartridge system is followed, and films may be exchanged and replaced in the open air. The focus must be obtained with the greatest accuracy, because not only does the least departure from the correct plane—owing to the short focus and large aperture of the lenses employed—produce a much greater effect than under ordinary circumstances, but any such want of sharpness will be rendered still more palpable by the enormous degree of amplification the minute pictures have to undergo.

The receiving spool is connected with a handle outside the camera, by means of which, when all is ready, the film is wound at a regular speed from its unexposed box on to the exposed spool, and during the journey the whole of it passes in front of the lens. But if the motion were a steady and continuous one, the only effect would be to produce a continuous blur, to obviate which is the function of the sprocket wheel and shutter. By means of the sprockets which engage in the perforations of the film it is pulled forward by a series of quick jerks, alternating with comparatively longer periods of rest; the longer the resting periods in proportion to the periods of motion the greater the efficiency of the instrument so far as exposure is concerned. The ratio between the two in the best instruments is at least 2 : 1.

But simultaneously with the jerk forward of the film, a rotating or reciprocating shutter comes into action, and momentarily closes the lens during the period the film is in motion, uncovering it again the instant the period of rest commences, these alternate motions taking place at the rate of from fifteen to thirty times in a second, from which, as we have already said, it will be evident that the very greatest precision of working and accuracy of perforation are necessary in order to secure register of the picture afterwards, upon which clearness and steadiness depend.

In the case of a steady continuous motion the object would be easy of attainment with ordinary gearing; but it is not quite so simple a matter when the intermittent character of the movement is considered, and it is here where the function of the sprockets and perforations comes in. In some instruments the sprocket-wheel itself communicates the intermittent action to the film; in others it imparts to it a steady continuous motion, while other means are taken to give the necessary jerk forward; but in all cases the method by which the result is produced is much the same. The jerk forward of just the length of one picture leaves that amount of "slack" on the film, which, during the period of rest of the remainder, is taken up by the steady revolution of the receiving spool. The sprocket-wheel, or cylinder, also serves the purpose, as will be evident, of a regulator of the amount of film wound up by the receiving spool, as without its intervention the increasing diameter of the spool would cause the film to travel at a constantly accelerating speed.

We have dwelt at greater length upon the production of the film negative than the objects of this work would seem to render necessary; but we have done so intentionally, because the principles involved are precisely the same as those which rule in connection with the projection of the pictures. We may pass over the production of the positive film without saying more than that a similar strip of sensitive film is passed through the machine in contact with the negative strip, receiving exposure to the light of a paraffin lamp or gas flame as it passes the lens aperture or when special printing apparatus is used, as it passes the aperture provided for the purpose, the respective films being re-wound separately, the positive on to the receiving spool, the negative on to another specially provided. The development and further treatment of the two films, moreover, forms no part of the object of this work, so we may pass on to the projection.

The process consists essentially in a repetition of the operations already described, with the difference that the apparatus is placed in the axis of the cone of light emanating from a lantern of ordinary or of special construction, but so far as the optical system is concerned, the projection of animated photographs differs in no respect from that of ordinary slides. We have, in fact, only to deal with the mechanical arrangement employed to bring the pictures into the beam of light. This consists of an apparatus

similar to, or identical with, that used in the production of the negative, and although, as we have said, special arrangements are provided for projection only, it would seem to us that a more perfect result should accrue from the use for the latter purpose of the identical apparatus employed in making the negative. Still, this is a matter rather of convenience, or one that will depend, in great measure, upon circumstances, and until the making of the negative films becomes a regular part of the exhibitors' duty, the special projection apparatus will continue to have its value for those who merely purchase or hire the negative films ready made.

The special apparatus differs in no essential respect from that used in making the negative, except in so far as, for exhibiting purposes, the shutter is not so necessary a portion of the mechanism. Some of the projection machines have shutters, some are "shutterless"; while in others, again, that detail may be employed or not at the option of the exhibitor. The points to be observed in connection with the shutter are—first, that it necessarily causes a certain loss of light, and by its intermittent action, gives rise to an unpleasant "flicker," or unsteadiness, which in some of the earlier machines was most distressing. It will be evident to all who are acquainted with lantern work that when pictures of the size we have mentioned, representing as they do but a quarter of the area of the ordinary lantern slide, are enlarged up to anything like the dimensions usual with the latter, the necessity for the very best light possible will be only too obvious; and besides the greater degree of enlargement, it must also be borne in mind that the celluloid films are by no means so clear and *transmissive* as good glass slides. Taking these circumstances into consideration, we can fully sympathise with the desire to do away with the shutter when it still further decreases the available light by at least one-third.

But, on the other hand, the suppression of the shutter gives rise to another fault, a streaky appearance of the picture or "raininess," as it has been termed, from a similarity to falling rain. This is caused by the motion of the film, which takes place in full view, and though each separate motion is extremely brief, it naturally follows from what has already been said about persistence of vision, that that property must exercise an effect in connection with the moving periods precisely proportionate to the time occu-

pied by the separate phases. If the motion of the film were continuous, it would result in a complete blur, or a series of stripes representing the salient features of the scene. If the motion consist of alternate periods of two-thirds rest to one-third of motion, the blur must still be visible in the form of "raininess." Clearly, the only remedy for this state of things, is to increase the proportionate difference between the periods of movement and of rest as much as possible. It has also been proposed to employ a shutter of translucent material, which, while permitting a portion at least of the light to pass, would obscure the details of the moving picture, and obviate the streakiness by converting it into an evenly diffused illumination. This is one of the points to be considered in the selection of apparatus; beyond that individual perfection of mechanism is about the only matter to study.

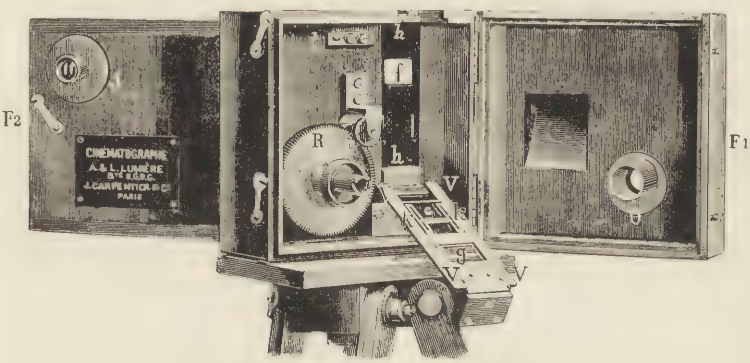


FIG. 56.—LUMIÈRE CINEMATOGRAPH CAMERA.

Perhaps the most representative of the all-round instruments, or those that perform the whole of the operation, is the Lumière Cinematographe, which forms camera, printing frame, and projection apparatus in one. The interior arrangements of the instrument, as employed for taking the photographs, is shown in Fig. 56, though essential portions of the mechanism are hidden, for which reason we can attempt no detailed description of it, merely referring our readers to the general remarks already made. In this apparatus the intermittent progression of the film is produced by the reciprocating action of an eccentric crank operating alternately upon the sprockets which draw the film forward, and the adjustable shutter that eclipses the

picture during the periods of motion. This eccentric motion takes place eight times for each revolution of the crank, and the relative periods of rest and of motion are about as 2 : 1, that is, the light is actually thrown on the screen for two-thirds of the total period, and obscured for one-third. The shutter is constructed in sections, in order to allow of adjustment in size when necessary. Fig. 57 will give something of an idea of its arrange-

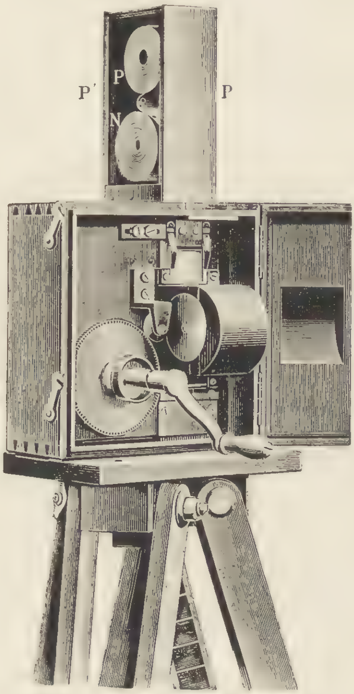


FIG. 57.—LUMIÈRE CAMERA AND PRINTING SLIDE.

ment when applied to printing purposes, though, of course, in actual use it would be closed; and Fig. 58 gives a rough sketch of a safety projection apparatus in which a globular flask of water is made to take the place of the ordinary condenser. This arrangement not only concentrates a more powerful beam of light on the small picture, but absorbs a large proportion of the heat as well. At the same time it will be noticed that a hinged shutter

or cap is provided between the source of light and the film to obviate any danger from heat, and this shutter is kept closed whenever the film is stationary, and only raised when the ma-

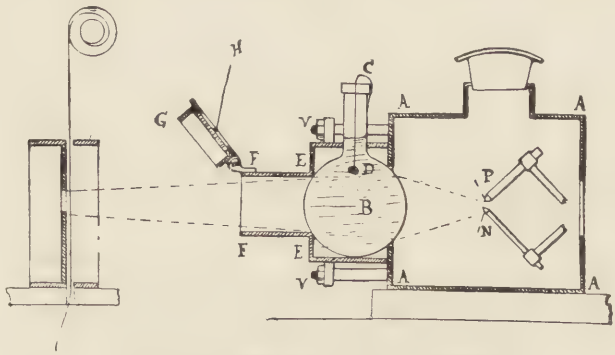


FIG. 58.—LUMIÈRE SAFETY LANTERN.

chinery is set in motion. The small object marked D is a piece of coke suspended in the flask to prevent or minimise ebullition, when from long use the water is raised to boiling-point.

The motor-pictoroscope of Mr. W. C. Hughes, of Kingsland, is

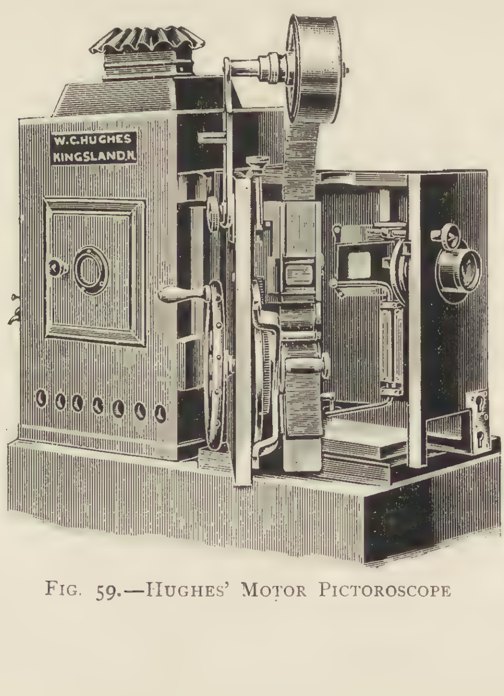


FIG. 59.—HUGHES' MOTOR PICTOROSCOPE

one of the instruments intended for projection only, and is shown attached to an ordinary projection lantern in Fig. 59. In this the usual sprockets are replaced by a piston and plunger, by which it is claimed that a smoother motion of the film is obtained. A shutter is provided which is so arranged that it can be removed at will even when the machine is in use. By increasing the rapidity of the changing action, or, in other words, the proportion between the periods of rest and motion, and dispensing with the shutter, the "rainy" effect is said to be entirely obviated as well as "flicker," and a gain of thirty per cent. in the illumination effected. The shutter is to be employed only in the case of dark or dense films.

The next diagram (Fig. 60) shows the method by which the

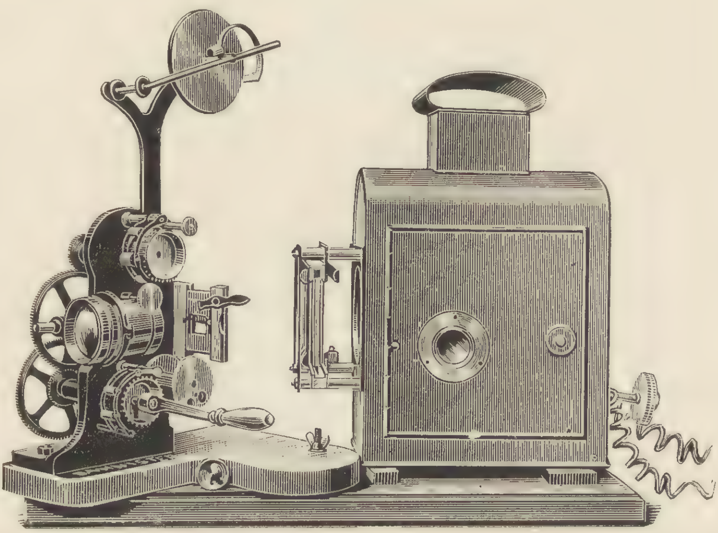


FIG. 60.—WARWICK TRADING CO.'S BIOSCOPE.

separate projection-mechanism is attached to an ordinary lantern. The instrument figured in this case is the Bioscope of the Warwick Trading Company, of London, which possesses some good features. The frame, it will be noticed, consists of a solid steel casting, which renders it impossible for the shaft and bearings to get out of adjustment, and at the same time provides a firm and steady base by which to attach the whole instrument to the table or other support. In this instrument, too, the shutter

has been dispensed with, and a gain of at least one-third secured in the illumination, while the flicker and "rain" effects are equally avoided, the latter by increasing the proportion between the periods of rest and motion to 8 : 1. It will be noticed that the base by which the instrument is attached to the table is provided with a clamping-screw and fly-nut, shown in the diagram immediately below the position of the ordinary slide-carrier. This is of great importance, and enables the instrument to be swivelled round out of position and replaced instantly without losing the adjustment. Thus, if while changing films, or for any other reason, it be desired in the course of an exhibition to substitute an ordinary projection lens for the Bioscope, it can be done without any trouble.

There are not wanting signs at the time these lines are written that before long animated photography will be brought

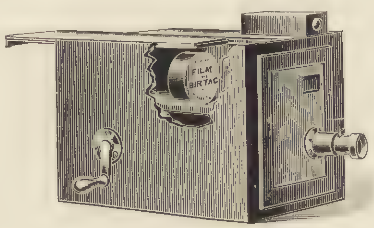


FIG. 61.—THE BIRTAC.

within the range of the amateur. The first important step in that direction has been taken by Mr. Birt Acres, already referred to as one of the earlier workers in this field. The idea has been to supply at a reasonable price a complete apparatus by means of which an amateur may take, develop, and show at home, or on a small scale, whatever scenes or events may strike his fancy. The Birtac—which is the name given to the instrument—takes a picture on a rather smaller scale than the usual instruments, which it is capable of enlarging, by means of the special incandescent gas burner supplied with it, up to 3 feet or 4 feet diameter, which is fully large enough for all home purposes. By utilising a special method of securing higher pressure and better light, the pictures may be increased to 6 feet or even larger, but the smaller dimension will suffice for most purposes.

The outward appearance of the instrument is shown in Fig. 61,

from which it will be seen that it is no larger than an ordinary hand camera; and Fig. 62 shows the arrangement in conjunction with a specially devised lantern supplied with it, by which the pictures are projected. The skeleton diagram (Fig. 63), shows in detail the working of the apparatus, and by its means the course of the film from the unexposed holder C to the receiving spool N, on which it is wound after the picture is taken can be traced. The essential point in which this instrument differs from most others is the manner in which the intermittent motion is communicated to the film. This is effected, not by the direct pulling or dragging action of spasmodically-working sprockets or pins, which quickly damage the perforations of the film and give rise to irregularity, but by a projecting arm on the revolving plate, H. At each revolution

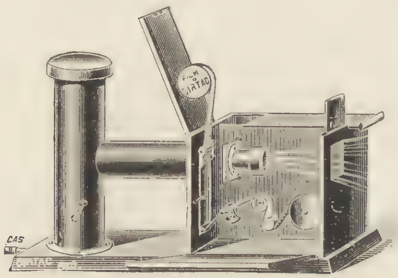


FIG. 62.

this arm, over which the film passes, in taking the position shown in the diagram, draws the film into a sort of loop between E and J; as the projecting pins on the steadily-revolving cylinder, J, prevent the film being drawn *backwards*, it follows, as a matter of necessity, that at each revolution the film is drawn forward a certain distance by a rapid jerk, and during the short period of the revolution that covers that jerk the lens is closed, and only reopened when the film has become stationary again. Most of our readers are more or less familiar with the action of the sewing machine, and we cannot do better than liken the action just described to that of the needle and thread of the familiar household instrument.

We are informed by Mr. Birt Acres that, with mechanism similar to this he has taken as many as one hundred photographs in a second, and he claims for it greater smoothness of working, and less risk to the films than when direct-acting sprockets are

employed. Besides this, it is possible to so adjust the position of the projecting arm on H as to vary the length and duration of the jerk forward to any extent, and, in fact, to make it occupy almost any proportion of the total period of revolution. In the Birtac the film is stationary for seven-eighths of the total period, so that where, for projection purposes, the shutter is dispensed with, the usual troubles are reduced to a minimum, if not absolutely eliminated.

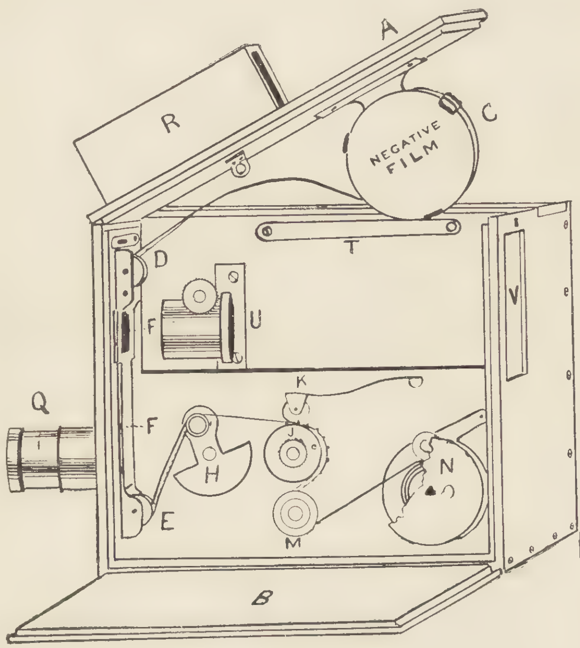


FIG. 63.

When used for projection purposes, the lens is removed from Q to U, and the apparatus arranged as in Fig. 62. The whole arrangements for development, printing, and finishing are so complete, and the apparatus generally so compact, that we have little doubt but that in the coming season animated photography and projection will begin to take a recognised position amongst amateurs.

It would be impossible, without still further extending an already lengthy description, to even mention a tithe of the instruments and accessories the practical worker will soon become familiar with. But we trust sufficient has been said to give our readers an idea of the principles of animated projection.

CHAPTER XVI.

PRACTICAL WORKING OF THE LANTERN, OIL LAMPS, BLOW-THROUGH, AND MIXING JETS.

LITTLE requires to be said with regard to lighting and using an oil lamp in the lantern. The lamp itself must be thoroughly clean outside and in, the wick or wicks accurately trimmed, and the full flame turned up not all at once but gradually; the wick ought at no time to be turned so high as to cause a flare; if once this mistake is made the lamp never seems to burn so well till all has been cooled down and the wick retrimmed. With paraffin lamps it is a common and commendable practice to put a lump of camphor weighing (say) one-half ounce with half a pint of the oil. This addition certainly whitens the flame.

As a rule there is no adjustment for raising and lowering an oil lamp in a lantern, but we require by pushing the lamp forward or pulling it backward to get the flame as nearly in the focal point of the condenser as the size of our radiant will permit. This we judge by watching the disc of light thrown on the screen; coloured edges on the screen mean that the light is not in focus. With many-wick lamps we are apt to have an ill-defined image of flame down the centre of the disc; we are informed that all lamps do not necessarily show this defect, and we can say that with all the lamps we have used of moderate pretensions to good quality, the defect has been so slight as not to entail absolute failure.

Our chief business, however, is with the lime light, and to it we now address ourselves.

The "limes" are either turned from solid pieces of "hard" or "soft" limestone, or they are composed of a mixture of substances the nature and proportions of which are kept secret. The best limes, so far as light-giving qualities are concerned, are those turned from the natural limestone, but for some reason they are never turned true, the hole up the centre is seldom true, and the cylinder-shape is never accurately kept. The limes known as "Excelsior" are turned accurately enough, but are slightly inferior as radiants.

As, however, the distance from nipple to lime is a factor of considerable importance in producing the best light, and as of necessity this distance varies as we turn the badly-shaped limes, the Excelsior limes may actually give the better light. If we could get the "Nottingham" limes truly turned we should never use any other; as matters stand we use Excelsior or Nottingham as they come to our hand, except for a *very* powerful light, when the Excelsiors are not suitable. Probably the best lime for the blow-through jet is the "Excelsior," which is too soft for the mixing jet.

The limes are packed in hermetically sealed tin boxes, with a quantity of powdered quicklime, or in glass bottles with luted corks and usually without the quicklime. The limes have a great avidity for moisture, and will quickly go wrong if any moisture reaches them; so we must take every precaution to prevent the access of damp. Various plans have been tried to secure the limes from damp; our favourite system is to wrap a piece of paper round each lime and dip it into "paraffin wax" just above melting point. Some makers send out their limes already rolled in paper; this gave us the idea of the paper, for without it the paraffin is likely to stick to the lime cylinder. Mr. Hepworth points this out, and suggests the precaution of keeping the paraffin wax at a low temperature. Opticians sell long brass tubes to hold one dozen, six, or three limes end to end; these tubes have well-fitting screw lids, and are very useful. To one of these we added a little chamber in the lid, fitted with fine gauze; into this chamber is put calcic chloride, which is not without use as a protection for the limes against damp. In any case a tin of limes once opened is no longer a safe receptacle; more than once we have known a tin burst, and ten or eleven limes lost under such conditions. At one time we used a strong wide-mouthed glass bottle, into which we put lime cylinders, quicklime and all, as soon as we opened a tin, luting a tightly-fitting cork with melted paraffin; this was fairly satisfactory, but inferior to the brass cylinders mentioned.

Before "lighting up" for a display, two or three limes should be baked in an oven or on a hob; one is placed on the lime-pin and the hydrogen at once lighted. The best distance from nipple to lime is a matter to be decided by experiment, a mixing jet usually has its nipple much closer to the lime than a blow-through; the distance for a mixing jet may vary from one-sixteenth to one-quarter of an inch; we have seen the approach so close as almost

to amount to contact, and that in the hands of an excellent operator. In all jets there is an arrangement for adjusting the position of the lime with regard to the nipple ; of course the lime is moved, not the nipple.

We shall now suppose, first, that a blow-through jet is to be used ; we have a bag full of oxygen between pressure-boards, or a cylinder full of the gas, while the hydrogen tube is connected with the gas supply of the hall or room. If we use a bag we must have a weight of, say, fifty-six pounds, to which we may add one of twenty-eight pounds in case of need. Before lighting anything we open the bag-tap, and the O jet-tap connected with the bag by a rubber tube, having previously put the weight on the boards, and we allow the O to escape for about fifteen seconds to expel air from the gas way. If we omit this, the lighting up may start with a "pop," which is unpleasant. Then we shut off the oxygen and light the hydrogen, keeping the flame about an inch and a half in height or less. Next we gently and gradually turn on the oxygen, till we get a fairly good light without much redness or scattering of the gases. We may at this juncture turn the lime round a few times to see that it keeps its distance from the nipple and also to let it get pretty well heated all over. Next we turn up the H a little, at once the flame will become red ; a little more O will once more produce the blue and bright light ; and so on we may go H and O alternately, till at last we get to a point of brilliance that we cannot pass, and that may be taken as the best light the apparatus will give. Extra weight on the bag may or may not improve the light.

If we are using O in a cylinder with a regulator we proceed in just the same way. We open the cylinder first, then the jet tap, and here we go on increasing one gas after the other, H always first, till we find that we cannot turn on enough of H to redden the light, then the O tap will have to be manipulated till the best effect is produced. During these steps there may be hissing of the gases, but there is no danger, and when the light is right the hissing will stop, unless there is some defect in the jet.

Never put on or take off weights while the gas is burning. Never allow any person to lean on, nor in any way to touch a gas-bag while the jet burns.

Always light H first: always turn down O first. Always tie weights on to the pressure-boards, and never use round weights.

Never use any such things as fenders or boxes of glass plates for weight. Bags of heavy sand, made in suitable shape and tied on to the pressure-boards, answer well.

Amount of weight, *per se*, is not the important factor for a good light, but proportion of weight to diameter of gas-way is the factor that makes or mars.

If anything goes wrong, turn off the O at once, the H as soon after as possible.

A red light means too much H in proportion to O. A peculiar lurid blue point of light means too much O for the H.

The use of a mixing-jet entails two bags or two cylinders, with a greater weight in the case of bags, but it enables us to get a light certainly twice as brilliant as can be got through a blow-through jet, and moreover the area of incandescent lime is with the mixing-jet considerably smaller than with a blow-through, which, as pointed out in an earlier chapter, is an advantage of great weight when we desire the best optical effect.

When bags are used it is undeniable that there are possible dangers, but the contingency of accident is indeed remote if anything like common sense and common care be brought to bear on the operations. A mixture of oxygen and hydrogen in certain proportions will certainly on ignition explode, and that with violence if the gases are confined in any chamber offering much resistance. But in olden days the two gases used, as the custom, to be mixed in one bag and burned at a nipple, yet we are not aware of any accident having happened, nor was an accident at all probable so long as there was a pressure on the containing bag. Nowadays we put each gas in a separate bag, and we put the two bags in the jaws of one pair of pressure-boards which we weight; unequal pressure on the bags is, therefore, out of the question, and sucking back of one gas into the bag containing the other is seemingly physically impossible. But even supposing that the gases do get mixed in one bag, there is no likelihood, still less any certainty of an explosion, provided pressure is kept on the bag. All the accidents that have ever come to our notice have arisen from setting light to a mixture of the gases in a bag not under pressure, and no reasonable person is likely to do such a thing if he is sober, and aware of the effect of igniting such a mixture. Even supposing a bag contains hydrogen alone it is a foolish thing to bring a light near, especially if there is no pressure on

it. Hydrogen burns on being mixed with air, but hydrogen alone is not combustible, nor a supporter of combustion.

A lighted candle thrust into pure hydrogen will be extinguished. Even if hydrogen and oxygen are mixed, but one of the gases is in large proportion to the other, say nine of H to one of O, or nine of O to one of H, there is no explosion or ignition, the gases ignite slowly and there is steady combustion. But two parts of H to one of O will explode with violence on ignition. We gather, then, that even if a little of one gas gets into a bag containing a considerably larger proportion of the other gas, there is no danger of violent explosion, so that in order to produce an explosion we would almost require deliberate intention. But each bag should be used for one gas alone, and never for the other gas, and each bag should be conspicuously marked with "O" or "H," both on the side and at the wedge. And if there is any doubt at any time as to the contents of a bag, the test should never be made with a light placed anywhere near an unweighted bag. Gas cylinders, in like manner, should be conspicuously marked, preferably by being painted in different colours.

We suppose the two bags to be filled each with its own gas, and placed between the pressure-boards. First we place the H bag in position, taking care to push the tap well through the hole in the pressure-boards intended for it, we then let down the partition, and on this we place the O bag. Then the bags are connected with the jet tubes by strong rubber tubes, taking care to spring the rubbers well up on the taps and jet tubes. Having put our weights on the boards we allow a little of each gas to escape at the nipple of the jet and thereafter close the taps. The lime cylinder being on its pin, and the surface of the lime about one-eighth of an inch from the nipple, we light the hydrogen. (If the "cut-off" arrangement (Fig. 32) is used, the cut-off cross-piece is turned so that both gas-ways are full open.) Now we turn on a little O; when the flame is a brilliant point we raise H a little, then the O again; and so on till we have the best light we can get, or until the jet begins to "roar" beyond endurance. (Having got the best light, if the cut-off is in use, we turn the latter completely off, the H will continue to burn gently, and on turning the cut-off open again we shall find the light as we left it—at its best. Using the cut-off with cylinders alone does not answer, but with Beard's Regulators on the cylinders, it will

work quite well.) For a mixing-jet where two bags are used in one pair of pressure-boards, having a surface of top of 40 × 30 inches, 112 lb. will be found a good average pressure. In our experience no "composite" lime will stand the amount of heat produced by this pressure and a good jet; a "solid" lime will be required—*i.e.*, one turned from limestone.

When we are dealing with multiple lanterns and dissolvers, we have, of course, to follow the above course with each jet—getting all the jets to burn as nearly as may be with equal brilliance, a matter of no slight difficulty at times. But when once we have got the jets to work equally well, a good dissolver will ensure the changes being properly made, and if the slides are of equal density we shall have equally brilliant images on the screen.

As has been already said, the light should be arranged and everything centred and focussed before the audience begin to enter the hall. This is all the more important when the lantern is placed among the audience. The cut-off arrangement enables us, having once regulated the light, to turn it down till we require it for the lecture, and then to get it in an instant as we left it. If the "cut-off," or an equivalent, be not available, we must at the beginning of the lecture turn up the gases again as neatly and as quickly as we can.

The cautions given in connection with the blow-through apply equally for the mixing jet, and ought to be studied beforehand, and committed to memory.

CHAPTER XVII.

PREPARATIONS FOR LECTURE.

A PERSON lecturing for the first time cannot reasonably expect to meet with such success as he may hope to achieve after some practice. This remark holds good for an ordinary lecture or public address of whatever kind, but it has much greater weight when applied to lectures illustrated by means of the lantern, with all its incidental cares. A few remarks suggested by experience may therefore not impertinently nor inaptly be addressed to the young or the intending lecturer, and these remarks naturally range themselves under two heads—viz.: points to be noted with regard to the actual lantern operations; and points to be attended to by the lecturer during his actual occupation of the platform.

If any *fiasco* ever takes place in regard to a lantern display, it is most likely to happen through some part of the apparatus being left behind or not procured. And if anything is forgotten, it is pretty sure to be a small article. One does not, as a rule, forget to pack and carry the lantern, nor the pressure-boards, we are far more likely to forget the key for opening the valve of the cylinder. The limes are not seldom left at home, and, like the valve-key, are almost impossible to get unless the lecture is to be given in a city or large town. We propose, therefore, to give, as a sort of *memoria technica*, a full list of all the articles required. This list will be found on page 137.

It is always well to examine the hall where the lecture is to be given, before it is actually time to start the erection of the screen. Sometimes the hall or the platform is of such a construction as to prevent the use of the ordinary screen or screen-frame; sometimes the arrangements are such that we can advantageously dispense with the screen-frame altogether; sometimes there is great difficulty in finding a suitable site for the lantern; and very often, put the lantern where we may, there is a gas bracket or some such obstacle between the lantern and the screen. If we see these matters a day beforehand, we can frequently have them remedied

in time; if we do not see the difficulties till the last moment, we may not have time to remove them. Gas brackets in particular have to be seen to; we have more than once had to cause the removal of a rigid pendant.

It is by no means necessary to have the lantern on the middle line of the hall; it is often very convenient both for lanternist and audience to have the lantern quite at the side of the hall; in such a case, of course, the screen is not erected at right angles to the central line of the hall, but at a greater or less angle to it. If there is no gallery or other eminence at the back of the hall and at a suitable distance from the platform, this plan of "angling" the screen and putting the lantern at one side of the *auditorium* is not only passable but very desirable, for the lantern is not surrounded by the audience and none of the audience can be directly behind the lantern, and so be dazzled or have the view obstructed by it. We strongly recommend the placing of the lantern at one side, where no gallery is available right in front of the screen. Anything is better than having the gas-bags or cylinders closely surrounded by the audience.

Undoubtedly the best site for the lantern is the front of a gallery straight in front of the screen. Sometimes, however, this gallery front is too far distant from the screen for the disc we require. Roundly speaking, the diameter of the disc should be about one-third of the length from back to front of the hall. If we have a hall forty-five feet from gallery to platform we shall get a fifteen feet disc with a nine inch lens, about a seventeen feet disc with an eight inch lens; if our distance be sixty feet we shall get a twenty feet disc with a nine-inch lens, a fifteen feet disc with a twelve-inch lens. If we have only one projection lens, say of eight inches focal length, we shall frequently have to go to the body of the hall with our lantern. One thing we would try to impress upon our reader; a good small disc is vastly superior to a poor large one, and the small bright disc is *better seen* than the larger poorly lighted one. The foremost of the audience should be kept well back from the screen, the larger the disc the further back the front row of seats should be placed. In most cases the best place for seeing is at about a distance from the screen of three times the diameter of the disc, not less certainly than twice, but, of course, short-sighted persons will see better if they are closer to the screen than these distances.

We will suppose the screen to have been erected, the site for the lantern chosen, the lantern unpacked and on its table or stand in the selected position. In choosing the spot for the lantern we must take care that the optical axis of the system is perfectly perpendicular to the screen; in other words, that the lantern is right opposite the centre of the screen. The tilt required for the screen may be judged with fair accuracy by eye, but a safer way is to centre the disc on the screen, place a slide in the carrier, and tilt the screen until the foreground and top of the picture are alike in focus. For centring the disc we use a blank slide, that is to say, a circular mask mounted between two glasses of lantern slide size, the centre of the circle being marked on one of the glasses with ink or a piece of paper gummed to the glass. (To make a good ink mark on glass lick the glass with the tongue, let it dry, and then put on the ink. If soot is dusted over the ink when dry the mark will be all the better.) It must not be forgotten that though the whole of the circular disc may be shown, an oblong (or cushion-shaped) picture may overlap the screen, so allowance must be made for this. In any case, the picture must fall *well* within the limits of the screen, the half-lighted margin round the real picture forms a nice mounting for the latter. If it be seen that one side of the picture or of the mask image, is more sharply focussed than the other, the screen is not at right angles to the optical axis, and either it or the lantern must be shifted.

The beginner should certainly see to all these matters some hours before the show is to begin: the lantern ought to be in position and the lenses focussed, so that when the time comes to light up there may be no alteration of position required. Two or three limes may also at this stage be put to bake in an oven, or on a hob; a well-baked lime is a considerable advantage.

Of course, if either or both of the gases are to be made by the operator, it should be done a few hours before the display is to begin, and we advise the tyro to make *plenty* of *gas*. A few pence wasted will be well repaid by peace of mind. The oldest lecturer is not without his qualms as to the gas supply, for one never knows what accident may occur. Gas-bags should on no account be left without surveillance in an open hall, even if they be locked; and if cylinders are used, the owner should not surrender charge of the keys. There are always clever fellows knocking about who

are eager to show off their knowledge, and a cylinder of oxygen yields many beautiful experiments.

Immediately before the final lighting up the front lens should be well warmed. The condenser very quickly warms when the gas is lighted, but the front lens does not get so much heat, as it warms slowly, and is apt by "sweating" to spoil some of the first pictures. But it may be removed only after the image is centred and focussed, so that as soon as the lens is replaced the image is found to be *in statu quo antea.*

During this afternoon visit to the scene of action the lecturer should see his platform arranged; his desk, chair, light, signal, water-bottle, and glass. It is too late to do these things when the audience begins to come in. The lanternist may see that his slides are in order, but he must not leave them in the hall. Practical jokers are not extinct, and fools are numerous.

CHAPTER XVIII.

MANAGEMENT OF LANTERN DURING LECTURE.

Having arranged all the apparatus so as to get a satisfactory light, we proceed to centre the disc on the screen to "register" the discs if we propose to dissolve, and to focus the light and the projection lens. These operations are all to be done by experiment and cannot usually be performed in any stated order, they depend much on each other. Perhaps the easiest plan is to focus the light first. We begin by projecting *some kind* of disc on the screen, a blank slide being in the carrier. (The carrier itself is usually centred by removing the projection lens, and looking down the nozzle till by eye we get the aperture in the carrier central with the nozzle. A very good plan is to put a "stop" or make a mark on the carrier when centred, so that we may be able at any future time to centre it at once.) Probably the disc at first has no particular shape and is unevenly lighted; by pushing and pulling, and moving to one side and the other, and by raising and lowering the jet we finally get a brilliant round disc evenly lighted, and with sharp colourless edges, and if the lantern is properly placed, the disc is in the centre of the screen. As already said, if the disc-edge is not equally sharp all round the lantern is not "square on" to the screen; if the bottom or top of the disc is unsharp the cant or tilt is wrong; if one side is out of focus the angle of screen to lantern is wrong. If any of the pictures are to be of shape other than circular we must try a mask of that other shape. We finally remove the blank slide, and put in the first slide of the lecture; this we very carefully focus, and we are now ready to begin.

If the lecture is to last, say, eighty minutes two limes will assuredly be required, three will be better if we have a chance of changing more than once. A pair of "pliers" should be at hand to remove the used lime, in fact a pair of plumber's pliers is what no lanternist should be without. The hole up the middle of the limes should be cleared out before the

lecture; sometimes the lime is not put on its pin without trouble, and anything savouring in the smallest degree of a hitch must be carefully avoided. The lime must be turned at intervals, greater or shorter, according to the force of the jet. A blow-through jet requires its lime turned, say, every four minutes; a mixing-jet under heavy pressure works best when the lime is almost constantly on the move. Clockwork has often been used to drive the lime slowly round. Anyhow, a deep pit on the lime must never be allowed. Of course, a soft lime pits more readily than a hard one.

It is a sign of mismanagement when an operator has to keep altering his jet-taps; if the light first attained be of proper quality, and the jet properly made, no tampering with taps should be needed at all. It is just possible that a few minutes after the lighting up a slight alteration may be required (for some reason when this happens it is the oxygen that requires to be slightly increased, as a rule), but in a general way we do not require to alter anything until the pressure in the cylinders or bags falls materially lower, which is always near the end of a lecture and often does not occur at all. But if the light becomes too red or too large in extent, we are forced to reduce the hydrogen, which is, perhaps, preferable to increasing the oxygen. Unless the jet is in some way clamped in its position, care is necessary to avoid knocking the end of the jet or the rubber tubes, and so uncentring the light. Moreover, the slides should all slip sweetly into the carrier; we rather object to a carrier into which slides are *dropped*, as the carrier is apt to be knocked out of centre unless it is clamped as suggested at page 26.

The slides must all be in order and convenient to the hand of the lanternist, and they should be distinctly marked so that the lanternist may know in the semi-obscurity of the lantern-vicinity how the slides go into the carrier without having to hold them up between his eye and the screen, or near the back of the lantern. In England, if there is any standard slide-mark at all, it is this: The slide is laid down as the picture actually appears in nature or is intended to appear on the screen, and two marks are affixed, one to *each top corner*. These two marks go into the carrier *next the light and downwards*.

Slides that have passed through the lantern should be kept quite apart from those still to pass.

CHAPTER XIX.

DEPORTMENT ON THE PLATFORM.

THE young lecturer is sure to be more or less nervous, but in different lecturers the nervousness shows itself in different ways. One is full of diffidence and tremors, another is assertive and inclined to "swagger." If the diffident one has himself superintended all the preparations, knows that his apparatus is good, and his gas plentiful, he may keep his mind quite at rest, he has done his "level best," and nervousness now may spoil the whole. If the assertive one will only realise that a forward manner is offensive to his hearers, and certain to vitiate his success in their estimation, he may, perhaps, subdue for the time his conceit.

There are some who think that glitter of brass on the lantern and gold lace curtains over the screen will make up for any shortcomings of the slides or of the lecture, while there are others who fancy that disregard of external appearances looks business-like and savours of the veteran lecturer. Probably both these parties are wrong, and excellence lies midway between the two extremes. All apparatus should be in thorough working order, and scrupulously clean, and the screen is all the better for having the frame-poles concealed by a tasteful, but simple pair of curtains. On the other hand, acres of bright brass do not make a good lantern any more than a dress suit constitutes a good lecturer. There is a very good story told of a lecturer whose lantern was so resplendent with bright brass work that he found the audience all sitting with their backs to the screen and their faces to the lantern; they could not believe that such a very grand instrument was not the intended object of their attention.

There should be a thorough understanding between the lecturer and the lanternist, certain signals should be arranged for communication between them in case of mistake. For example, if by some mismanagement a slide comes in the wrong order or reversed as to right and left, it is most awkward for the lecturer to hold a dialogue with the lanternist. It has already been stated that the neatest kind of signal consists of an electric communica-

tion between speaker and lanternist, the bell at the lantern being muffled. The effect is exceedingly good when the lantern can be hidden from the audience altogether, as in a little room at the back of the hall, the front of the projection lens coming close to a hole made for it, and the lanternist having a small window through which he can view the screen and platform. The writer once lectured under the following pleasant conditions:—A screen 30 feet square, and quite opaque, a disc about 28 feet diameter, the screen draped with red curtains at each side. The radiant, an electric arc of 12,000 candles nominal power, worked by an engine in another street. The lantern entirely hidden from view, and electric communication with the lantern room. The pictures came on the screen as if by incantation, for the lecturer designedly concealed his "push" from the audience.

The lecturer ought always to make a few remarks to the audience before turning down the gas or other light illuminating the hall, and while he is making these introductory remarks he should carefully study the faces in various parts of the hall, in order to learn whether all can hear him well. Ears turned to the front, and gaping mouths, are sure signs that the speaker is not heard, and he must alter his voice and enunciation accordingly. Shouting is never a good way of making oneself heard, a loud conversational tone is the utmost amount of force likely to be useful. Slow deliberate enunciation is what is wanted. Every syllable must be distinctly pronounced, and rapid utterance must never be practised. The nervous lecturer is almost certain to speak far too quickly, and consequently is very apt to stammer and get mixed in his ideas, so the more nervous we are the more carefully must we study slow, precise speech.

In a popular lecture jokes are valuable, in fact nearly necessary. But the jokes must not be too stale, a jest familiar to everybody is worse than useless. We must try to suit our jokes to our audience, jokes that convulse a Scotch audience are lost in England on the very same class of people, probably a successful "quip" for a California lecture would fall flat in Boston. We must not be vexed—or at least we must not show vexation—if our jokes miss fire, we must try again with a different projectile. The writer places considerable importance on a good stock of jests for popular lectures; if we cannot compose a sally of wit ourselves, we may find what suits the purpose in books,

and, as we said, provided the jokes are not really pre-Adamite, they are sure to tell, and add to the success of the lecture.

Sometimes a foolish audience is apt to become unruly when the gas is turned down. This is almost always the fault of the lecture or the lecturer. If the lecture is uninteresting, boys are sure to lose patience, and indeed who does not sympathise with them? It is a fearful trial of patience to sit in the dark and see poor slides and hear dismal inanities uttered. If such a case should occur, and if any serious interruption to the lecture took place we should simply cause the gas to be turned up, and decline to proceed unless order should be maintained. But the worst thing a lecturer can do in such cases is to lose his temper. If he keeps calm, and even benignant, it will be a *very* low audience that will not yield to his good nature.

In lantern lectures extending beyond forty minutes, there should always be an interval, during which the hall is illuminated with the usual lights. This affords a rest to all concerned, and allows the lanternist to change his lime and see that all his apparatus is in order. But the interval must not be long, five minutes is perhaps the longest that will be safe. If the audience is put into bad humour by being kept waiting the danger of a disturbance is increased tenfold.

Unless the lecturer is very glib of speech, and has his subject at his finger ends, the lecture ought to be written or printed. An extempore lecture, when good, is a grand success, but when poor is apt to be a dismal failure, and the lecturer is set down as a conceited fool for attemping it.

To those unaccustomed to prolonged stretches of public speaking, especially when nervousness is felt, a lecture of, say, eighty minutes, is a severe tax on the throat. Drinking large quantities of water only makes matters worse sometimes, a tiny tablet or pellet of chlorate of potash will be found as good as anything to take. Borax is sometimes added to the potash, but the advantage is very doubtful. Not much liquid of any kind should be taken before lecturing, but hot drinks, as tea and coffee, are the worst of all things.

No one but a very "old hand" can sing and speak in one lecture.

Ninety minutes is the longest time advisable for the duration of a lantern lecture.

CHAPTER XX.

ARRANGEMENTS FOR THE LANTERN IN A LECTURE-ROOM.

As one of the chief aims of this book is to simplify and increase the use of the optical lantern in lecture-rooms forming parts of universities, colleges, schools, and other educational and recreative institutions, we may do well to suggest a few of the steps that may be taken to render the lantern a permanent instalment of the place. In such a case it is indubitably the best plan to have an opaque screen, and the best screen is, as previously stated, a plastered wall, white and matt in surface. Almost equally good in all respects, most convenient in many, is a strong opaque "faced" screen, such as was described in a previous chapter. This may very well roll up like a map, to be let down at the teacher's will. If it is convenient to set up the lantern straight opposite and at right angles to the screen, the latter may be allowed to hang down naturally; if the lantern must go below the centre of the screen, the roller may be brought a few inches out from the wall at top, and the roller at foot of the screen may be placed and held close against the wall. If the lantern goes more conveniently on a higher level than the centre of the screen, as will be the case in many lecture-rooms of the amphitheatre style, then the roller at top may be as close to the wall as possible, while the roller at foot of the screen may be pulled out and held a few inches from the wainscot or lower part of the wall.

In nearly all cases, such as we are treating now, a ten feet disc will be ample, and a blow-through jet sufficiently powerful; indeed, a good acetylene jet will answer for such a disc. On the score of convenience the lime light will probably be found preferable, for the requisite illumination can be got up more rapidly than with oil, and the effect, especially with the ordinary run of slides and with objects projected through a lantern microscope or a polariser, or a prism, will certainly be better with lime than with oil or acetylene. We recommend a good-sized cylinder of oxygen, say forty cubic feet,

or else a metal tank of the gas, but not a bag if the cylinder or tank can be obtained. Of course, the tank would not be large enough to hold more than from six to ten cubic feet. Bags for such a purpose would be wasteful even if they were not tampered with by the students. While thus recommending the blow-through jet, we must say that we have almost entirely given up its use, preferring from every point of consideration the mixing jet with two cylinders and two regulators, or a gas generator and saturator, such as described elsewhere. For a lecture-room we should suggest one of the open-stage lanterns, such as Figs. 51 to 55; this kind of lantern is useful for every condition likely to arise. A part of the outfit ought to be the arrangement for showing opaque objects. For special illustrations such as spectrum analysis special accessories must, of course, be added.

The matter that seems to give teachers the greatest amount of perplexity is that of darkening the lecture-room during the day-time, and even when the gas is lighted. The gas is easily arranged by putting within reach of the teacher, the lanternist, or an attendant, a bye pass tap, whereby the gas of the room can be lowered "to the blue" without being extinguished. If the electric light be used for the room it can easily be switched off, and here it may be said that if electricity be used for the illumination of the room or building, we should certainly utilise it for the optical lantern, even were we restricted to an incandescent lamp. The electric light has its disadvantages for the lantern, but its performance is so good when in good order, and its convenience so great at all times that, when available, it should certainly be utilised for the purpose.

For blocking out daylight the simplest and best contrivance is a shutter on the "Louvre" principle. There is a shutter on the market known as Clarke's patent, and it answers the purpose admirably. It is made of slips of wood joined by strips of strong cloth, and simply folds up into a coil which occupies, when the shutter is open, a receptacle at top or bottom of the window. This appliance, when well fitted, completely blocks out light; it is opened and shut in a few seconds. But even this is not necessary to success, for a blind made of opaque stuff, fitted in runners, for instance, close to the sides of the window, will shut out light sufficiently for our purpose. Absolute darkness is not essential to even a good image on the screen, while a powerful

lantern will project a useful picture even when the room is only in semi-obscurity. We have seen a very successful series of lantern illustrations in a room where every person present was visible to the lecturer, though only dimly. But it must be understood that where pictures, and not mere instruction, are the object, the room should be as dark as possible; we only say that instruction of a class is possible in a dimly-lighted room. And if the lantern slides be dense, or the microscopic objects thick or heavily stained, then the room must be really dark.

Throughout this book the writer has had in his mind the instructor rather than the entertainer. The optical lantern, as a means of imparting instruction to classes, is only beginning to occupy the place it ought to fill on its merits. In the interest of teacher and student alike, we venture to hope that the optical lantern will soon take the place it deserves.

CHAPTER XXI.

ENLARGING WITH THE OPTICAL LANTERN.

As those who possess an optical lantern frequently wish to use it for enlarging from photographic negatives or positives, it may not be out of place to offer a few remarks on the subject.

If the original negative be of lantern-slide size, or if the part we wish to enlarge covers an area of not more than three and a-quarter inches square, we shall not require any alteration of our lantern with four-inch condenser provided the front lens racks out far enough, and there is sufficient space in the carrier opening to admit the larger negative. But if we propose to enlarge from entire quarter-plate negatives, we shall require a larger condenser, and so also for every increase of size. To find the size of condenser necessary to illuminate properly any size of plate which we may wish to enlarge, a simple rule is to take the diagonal of the plate; the diameter of the condenser must be a little more than the diagonal of the plate. Thus, to enlarge a "half-plate," 6½ × 4¾ inches (English size), a condenser of diameter not less than 8¼ inches should be used.

We are less tied down in the choice of a projection lens, as the focal work is practically immaterial for any such work as we are likely to attempt. But lenses sold for the lantern only, and not having their visual and actinic foci coincident, will not answer for enlarging, or will not answer the purpose nearly so well as a lens corrected for photography. But any photographic lens will be available, if it give rectilinear images, and if we can rack the lantern front sufficiently to give the lens play.

Manufacturers produce lanterns having the front so made as to stretch outwards from the stage to a considerable extent. Sometimes this motion is attained by bellows, sometimes by telescope joints—one probably is as good as the other. The reason for this extension of front lies in the fact that in order to get a focussed image twice the size of the original, the optical centre of the lens must be one and a-half times the focal length

of the lens distant from the negative to be enlarged. Thus, with a six-inch lens to get an enlargement twice the diameter of the original, the optical centre of the lens—usually very near the stop —must be nine inches distant from the negative. If a copy of size equal to that of the original be required, the front must rack out so that the centre of the lens can be placed at *twice* the focal distance from the object being copied. At the end of this chapter we give a table extracted from the almanac of the *British Journal of Photography*. This table shows at a glance the distances from centre of lens to object and to receiving surface for various degrees of enlargement or reduction.

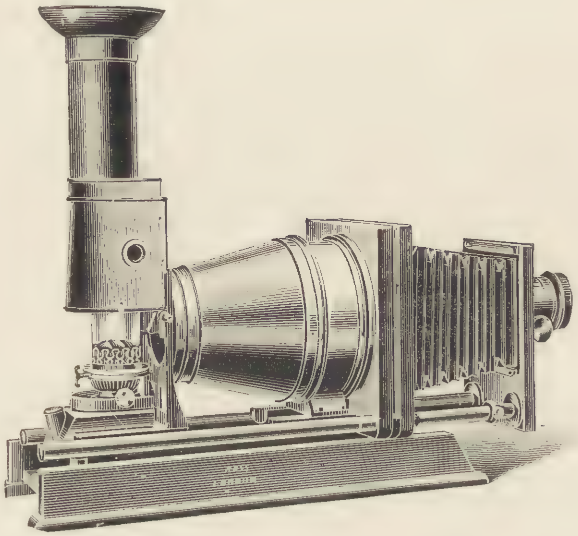


FIG. 64.—PATENT ENLARGING LANTERN.

Although, with the limitations mentioned, the ordinary projection lantern may be utilised for enlarging purposes, it is only with instruments specially constructed that complete efficiency, and particularly comfort, are experienced. There are many such special instruments on the market from which to choose, but one of the most serviceable in every respect with which we are acquainted is the Patent Enlarging Lantern issued by Messrs. Ross, Limited. This, with the exception of extending front and wood base is constructed entirely of metal, so that there is

nothing in the working parts liable to suffer from the effects of heat and lead to trouble in working. A feature in this instrument is the rising body, shown in the illustration raised, for the purpose of lighting; otherwise every adjustment even to filling the lamp can be performed from the outside. When closed, the lantern is absolutely light tight. The space in front of the condenser for the insertion of the negative is open on three sides, which renders it possible to work from portions of plates considerably larger than the lantern is constructed to take—a matter of some convenience, for instance, in enlarging a single figure from a group; while by the use of a suitable carrier it may be employed for projecting ordinary slides. The extending front, which is on the bellows principle, slides smoothly but firmly on telescopic tubes and provides ample range for any desirable focal length of objective. The working of this portion is sufficiently easy to admit of accurate focussing in case the lens is not fitted with rack and pinion. The lantern here shown is provided with an oil lamp; but it can also be supplied, we believe, for use with the limelight or electric arc lamp. Not the least important feature of this lantern is its extreme compactness.

For those who find it more convenient to use ordinary gas, Messrs. Butcher, of Blackheath, manufacture a special enlarging lantern fitted with the Welsbach incandescent burner, which is a distinctly useful instrument. Others of the commercial articles can, with little trouble, be adapted for use with acetylene.

The sensitive material on which we project and finally develop the enlarged image is, as a rule, the paper known to photographers as bromide paper, but it may be a slow gelatine, a wet or a dry collodion plate. The purely photographic part of the operations is out of place here; we may refer the reader to the "Processes of Pure Photography,"* or any other book of the same series treating of photographic operations.

The substances used for the photography of enlarged images are usually very sensitive to actinic light, and bromide paper, for instance, will be damaged if any stray light from the lantern or from the illumination of the apartment reaches it, unless such stray light be of a yellow or red colour. If there is much light about the apartment, however non-actinic it may be, the

* "Processes of Pure Photography," by Burton and Pringle.

difficulty of focussing the image will be found great. The best plan is to enclose the entire lantern in a box, letting the lens-front alone protrude, and allowing the necessary draught to reach the light either by "trapped" apertures, or by some arrangement of thick cloth. Reflections, it must be remembered, must be kept from the sensitive material as sedulously as direct stray light.

The paper, or other sensitive material, is to be placed in front of the projection lens, and the receiving surface must be perpendicular to the optical axis of the condensing and projection

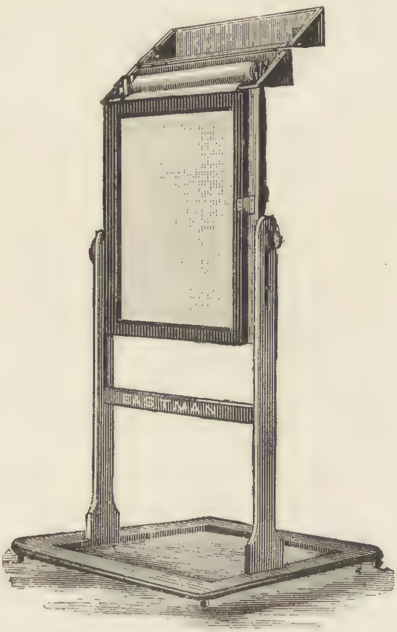


FIG. 65.—ENLARGING EASEL.

systems. If this is not attended to some part of the enlarged image will surely be blurred. Paper may be tacked with drawing pins to a board or a wall, or it may be held on an easel in front of the projection lens. The easel may be free on the floor, but it is better when convenient to have it either running on a track or sliding in slots or grooves along the optical axis of the system. Fig. 65 shows a very useful easel made to hold a long roll of bromide paper or cut sheets, as may be desired.

The accurate focussing of the projected image may be adjusted either by racking the projecting lens in and out, or by pushing the easel backwards and forwards. The former is perhaps easier; the latter always preferable. If accuracy in amount of enlargement is not of vital importance, the former method may be adopted. We may project the image and focus it either on a white surface, as a sheet of paper, afterwards replacing the white paper by the sensitive surface; or we may even pin the bromide paper over the plain paper on which we focussed; again, we may place on the lens a cap of non-actinic glass and focus directly on the sensitive surface, removing the non-actinic cap when the focus is adjusted. The question of exposure comes under the head of photography, so we shall not here discuss it at length. The actinic force of the radiant, the intensity ratio of the lens, the density of the object to be enlarged, and the sensitiveness of the receiving surface being all taken as fixed terms, the exposure varies directly with the areas of enlargement and inversely with the utilised area of the condenser.

TABLE FOR ENLARGEMENTS.

Copied from the "British Journal Almanac."

Focus of Lens.	Times of Enlargement and Reduction.							
Inches.	1 In.	2 In.	3 In.	4 In.	5 In.	6 In.	7 In.	8 In.
2	4	6	8	10	12	14	16	18
	4	3	$2\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{2}{5}$	$2\frac{1}{3}$	$2\frac{2}{7}$	$2\frac{1}{4}$
$2\frac{1}{2}$	5	$7\frac{1}{2}$	10	$12\frac{1}{2}$	15	$17\frac{1}{2}$	20	$22\frac{1}{2}$
	5	$3\frac{3}{4}$	$3\frac{1}{3}$	$3\frac{1}{8}$	3	$2\frac{11}{12}$	$2\frac{6}{7}$	$2\frac{13}{16}$
3	6	9	12	15	18	21	24	27
	6	$4\frac{1}{2}$	4	$3\frac{3}{4}$	$3\frac{3}{5}$	$3\frac{1}{2}$	$3\frac{3}{7}$	$3\frac{3}{8}$
$3\frac{1}{2}$	7	$10\frac{1}{2}$	14	$17\frac{1}{2}$	21	$24\frac{1}{2}$	28	$31\frac{1}{2}$
	7	$5\frac{1}{4}$	$4\frac{2}{3}$	$4\frac{3}{8}$	$4\frac{1}{5}$	$4\frac{1}{12}$	4	$3\frac{15}{16}$
4	8	12	16	20	24	28	32	36
	8	6	$5\frac{1}{4}$	5	$4\frac{4}{5}$	$4\frac{2}{3}$	$4\frac{4}{7}$	$4\frac{1}{2}$
$4\frac{1}{2}$	9	$13\frac{1}{2}$	18	$22\frac{1}{2}$	27	$31\frac{1}{2}$	36	$40\frac{1}{2}$
	9	$6\frac{3}{4}$	6	$5\frac{5}{8}$	$5\frac{2}{5}$	$5\frac{1}{4}$	$5\frac{1}{7}$	$5\frac{1}{16}$
5	10	15	20	25	30	35	40	45
	10	$7\frac{1}{2}$	$6\frac{2}{3}$	$6\frac{1}{4}$	6	$5\frac{5}{6}$	$5\frac{5}{7}$	$5\frac{5}{8}$
$5\frac{1}{2}$	11	$16\frac{1}{2}$	22	$27\frac{1}{2}$	33	$38\frac{1}{2}$	44	$49\frac{1}{2}$
	11	$8\frac{1}{4}$	$7\frac{1}{3}$	$6\frac{7}{8}$	$6\frac{1}{2}$	$6\frac{5}{12}$	$6\frac{2}{7}$	$6\frac{3}{16}$
6	12	18	24	30	36	42	48	54
	12	9	8	$7\frac{1}{2}$	$7\frac{1}{5}$	7	$6\frac{6}{7}$	$6\frac{3}{4}$
7	14	21	28	35	42	49	56	63
	14	$10\frac{1}{2}$	$9\frac{1}{3}$	$8\frac{3}{4}$	$8\frac{2}{5}$	$8\frac{1}{6}$	8	$7\frac{7}{8}$
8	16	24	32	40	48	56	64	72
	16	12	$10\frac{2}{3}$	10	$9\frac{3}{5}$	$9\frac{1}{3}$	$9\frac{1}{7}$	9
9	18	27	36	45	54	63	72	81
	18	$13\frac{1}{2}$	12	$11\frac{1}{4}$	$10\frac{4}{5}$	$10\frac{1}{2}$	$10\frac{2}{7}$	$10\frac{1}{8}$

It is assumed that the photographer knows exactly what the focus of his lens is, and that he is able to measure accurately from its optical centre. The use of the table will be seen from the following illustration :—A photographer has a *carte* to enlarge to four times its size, and the lens he intends employing is one of six inches equivalent focus. He must, therefore, look for 4 on the upper horizontal line, and for 6 in the first vertical column, and carry his eye to where those two join, which will be at 30—7½. The greater of these is the distance the sensitive plate must be from the centre of the lens and the lesser, the distance of the picture to be copied. To *reduce* a picture any given number of times the same method must be followed, but in this case the greater number will represent the distance between the lens and the picture to be copied ; the latter, that between the lens and the sensitive plate. This explanation will be sufficient for every case of enlargement or reduction.

If the focus of the lens be twelve inches, as this number is not in the column of focal lengths, look out for 6 in this column and multiply by 2 ; and so on with any other numbers.

Memoranda for a Lantern Display.

(*See Chapter XVII.*)

Lantern : Condenser, projection lenses, support.

Jet : Limes in box, tubing, needle for nipple (dissolver and tubing).

Lamp : (Wicks trimmed, oil with camphor, scissors).

Pressure-boards : Weights.

Bags : Bag-taps (back-pressure valves).

Cylinders : Regulators, key, spanner.

Screen : Screen-frame, cord, tape (curtains), a few staples or brass hooks with screw.

Reading-lamp : Signal, manuscript or book, list of slides in order —for lecturer.

Slides in box : List of slides in order—for lanternist.

Miscellaneous : Gas pliers, hammer and nails, screw driver and screws, gimlet and bradawl, instrument to bore out lime-hole, file, extra tubing, matches, tape measure. Lubricate taps of jet and bags (see that gas way of jet is clear).

For Oxygen Making : Retort, retort neck, tubing, oxygen mixture, heating stove and tube if for gas, purifying bottles—one or two—metal tubing for same, rubber tubing for same, alkali.

Squeeze all air out of bag, lubricate tap, lock for bag, bag marked O.

For Hydrogen : Generating bottle, scrap zinc, acid, purifier, metal tubing, rubber tubing, or large tubing and metal cone or "adapter" to join gas supply from main of building to the H bag, gas pliers and wrench.

Squeeze air out of bag, bag marked H.

Note: Never put grease or oil on metal fittings of cylinders, nor on regulators nor gauges.

Appendix.

NEW OXYGEN GENERATORS.

At various times attempts, more or less successful, have been made to devise apparatus that will automatically produce oxygen during the course of a display. There is no doubt that great as are the advantages of storing gas under pressure in metal cylinders as compared with the bag system, still there are very serious drawbacks in the use of cylinders. The weight of a moderate size cylinder, the dangers connected with very high pressures, the difficulty of making absolutely gas-tight couplings under these pressures, the expense of transport and the railway regulations attached thereto, the doubt as to the quantity of gas in a cylinder unless a gauge be used, the inevitable waste of gas when a cylinder is not quite emptied: these and other imperfections are inseparable from this system. It has long been felt that an automatic system of producing at least the one gas, oxygen, in the quantity and at the time required, would be a great boon to many, and we have lately seen apparatus which appears to fulfil the desideratum admirably, and by a further device connected with the lantern itself both gases are automatically produced during the working of the lantern, and in quantity commensurate with the requirements of the worker. Many years ago, in 1867 and 1868, the late Mr. Michael Noton, of Manchester, used plugs, or blocks, of "oxygen mixture" in small tube retorts, which were brought successively over a suitable Bunsen burner, and the gas when given off could either be collected in bags or used as manufactured. At a soirée of the Manchester Photographic Society, in January or February of the latter year, a lantern display was given, the gas for which was supplied as required by Mr. Noton's apparatus, a small tank, or receiver, being all that was necessary between the generator and the lantern. Mr. W. I. Chadwick, of the same city, used blocks or cakes of the same mixture in a specially constructed retort, and collected the gas in a bag, which acted as a reservoir. Apparatus for the same purpose was also patented in 1877 by Mr. Birrell and as well as

by Mr. D. Young, and to a certain extent the generators to be described are simply a further development of these earlier devices, but probably improved in details. The first apparatus we shall

FIG. 66.—THE "STAR" PATENT OXYGEN GENERATOR.

describe is known as the "Star" patent, and it is with advantage used in connection with a lantern, described on pages 142-143.

B (Fig. 66) is a wooden box about 15 inches square by 9 inches high, and contains a collapsible gas-bag, not seen in the figure,

surmounted by a hollow platform P, which rises regulated by the guides *g*, *g*, as the bag below is filled with gas. This part P is filled with water at time of use, and thus furnishes pressure on the gas-bag. If the platform P should rise too high from over-production of gas the valve *v* impinges on the abutment *a*, and the surplus gas is released. There are 5 or 6 short retorts, *r*, *r*, *r*, *r*, open at their proximal ends to the hollow upright *p*, and closed when in action at their distal ends by screw-plugs; *l* is an ordinary spirit lamp. These retorts can revolve on *p*, so that when the "cartridge" in one retort is exhausted, the whole "star" of retorts is turned, after the manner of a capstan, till a fresh retort is brought over the spirit lamp. When the platform descends below a certain point, indicating that the cartridge in use is exhausted, a signal is given to notify the fact. The retort-changing might be made automatic, but as each cartridge lasts about half an hour there is no necessity for such a complication.

The cartridges are of course moulded and compressed "oxygen mixture," and they are made hollow and cylindrical, fitting loosely into the retorts. They can be sent by post, and as is well known oxygen produced from potass. chlorate has a peculiarly fine light-giving quality in lime-light operations.

The oxygen begins to come off within five minutes of the heat being applied, it passes from the retort down the hollow pillar *p* into the water tank, thence to the lantern or saturator by the tube *t*, while the surplus goes into the bag at bottom of B.

The approximate weight of this entire apparatus—without the water—is 15 lb., so that it can be easily carried in one hand, and we have seen an example wherein a suitable lantern could be packed in the box B, above the rest of the apparatus.

The second generator is manufactured by Messrs. Riley Brothers, of Bradford, and has been christened the "Rilford." In this a single retort of cylindrical form is employed, and this is packed with cartridges of oxygen mixture at regular intervals with air-spaces between them. A lamp travelling upon guides beneath the retort is, by the rise and fall of the gas-holder, brought automatically under each cartridge in succession until the whole are exhausted, the manufacture of gas proceeding concurrently with the display of pictures. The charging of the retort will supply enough gas for a display lasting an hour and a-half if the Lawson saturator be used, or a little less if a good blow-pipe jet is

employed. The whole apparatus, which is shown erected for use, packs into two cases—measuring 34 inches × 5 inches × 5 inches and 14 inches × 14 inches × 16 inches respectively, and weighing, when packed, 46 lb. The diagram (Fig. 67) will serve to explain the working arrangements, A and N representing the two packing-cases, which serve to form a working stand when in use. B is a cylindrical steel retort with a clamped cap at one end, inside which is the tube, made to hold eight cartridges, which form a charge. The inner tube having been charged and placed in the

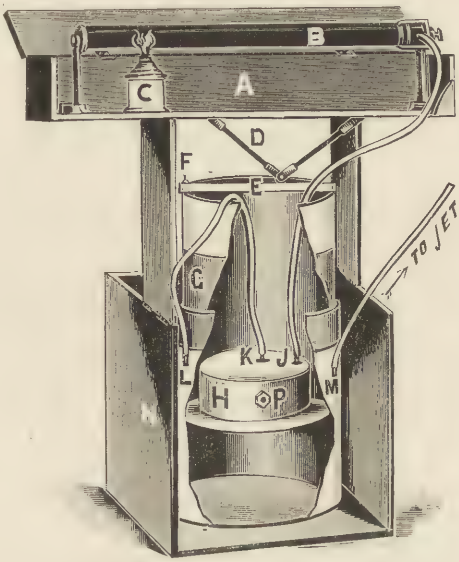


FIG. 67.—THE "RILFORD" GENERATOR.

retort, the cap is firmly closed and the retort placed in position on the standard, as shown; the lamp is lighted and pushed to the extreme left of the carriage guides, and in about eight minutes the gas will be given off and the container begin to rise. When the platform E rises sufficiently high it comes in contact with the jointed lever D, the right-hand end of which is fixed, the other free to slide, as it must, in the opposite direction, and this operates the automatic arrangement by which the lamp is moved. As the gas is used and the container sinks, the lever resumes its original position, and the free end, engaging a pawl on the lamp carriage,

moves it a certain distance to the right until it comes under the second cartridge, and so on until the whole are exhausted. If the gas is not used very rapidly, an escape-valve is brought into action to relieve the pressure. H is a washing chamber containing water, in which common washing soda has been dissolved, and the gas passes through this before it can reach the open part of the container. The weight of the washing-tank suffices to work the apparatus, but a better light is obtained if an additional weight of about 28 lb. is placed at the bottom of the container. For long displays a second retort is provided, which may be substituted for the empty one while the gas is burning. We find on trial that this apparatus works well.

NEW LANTERNS.

The lantern shown in Fig. 68 involves some new principles of construction which commend themselves to us. It is the invention of Mr. A. Sweetser, who calls it the "Auto-hydrogen," and we have been privileged to see it at work several times in conjunction with the "Star" oxygen generator already described. The lantern is extremely handy to work, and the light seemed to us specially fine in quality.

The base *b* is a saturator of simple and efficient type, packed with any suitable absorbent material damped with a light hydrocarbon, such as gasoline or ether. The capacity of this saturator is such that it will supply a strong light for several hours. The saturator may or may not be used; in the latter case it simply acts as a base to the lantern. The entire lantern, with the whole of the optical system, is pivoted on two pillars, one seen at *s*, so that when the lantern is tilted the whole of the optical system is tilted with it, and each part of that system retains its parallelism with the other parts. The advantage of this is specially obvious when, for instance, we have to tilt the bodies of a biunial or triunial in order to obtain "register" of the discs on the screen. These pillars, moreover, are hollow, and through them are conducted the gases to the jet by means of the rubber tubes shown, and if a double lantern is to be used, the pillars of the upper one

are simply screwed on to those of the lower, and all complicated arrangements of rubber tubes are avoided.

Another constructive novelty is that the front lens *o* can be adjusted along with, or independently of, the condenser from the *back* of the lantern, by means of the telescopic tubes *a* and the milled-headed screws seen below *j*. The stretch of the front from condenser *c* to front lens *o* is practically unlimited, and the "draws" are so constructed that "sagging" is wholly obviated.

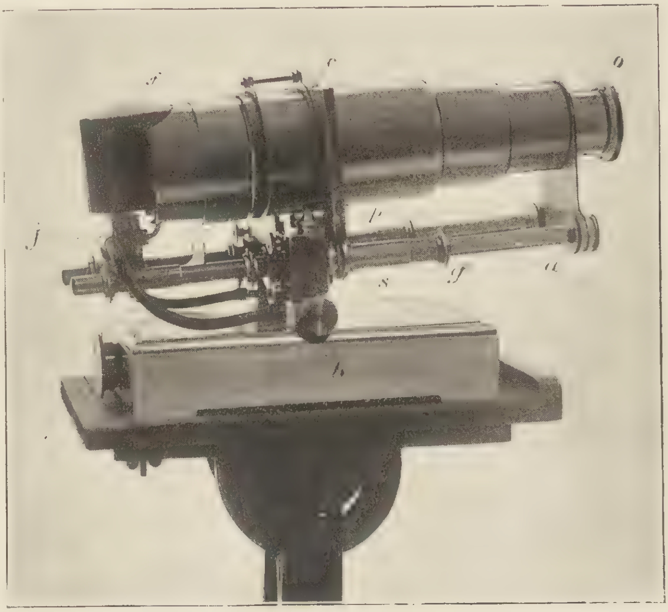


FIG. 68.—SWEETSER'S AUTO-HYDROGEN LANTERN.

The usual "body" of the lantern is replaced by a hood, *f*, made of fireclay or other refractory material, and perforated for the dispersal of heat. This hood acts admirably in protecting the lime from draughts of cold air, and by keeping the lime hot it prevents cracking and probably increases its light-giving property. A lime used in this lantern with gases from the generator and saturator shows very slight "pitting," even after prolonged use, and the condenser seems to be in no danger from deflection of

the flame from the lime. Any rays of light escaping from the fireclay hood are shut off from the audience by simple metal or other shades.

In details of construction the designer claims several advantages of simplicity and economy, but these matters are hardly suitable for elaboration here. The instrument is not yet on the market, so far as we know; but as all the metal parts can be stamped, or produced by ordinary press tools, the cost of the lantern will probably be small.

As evidence of the extreme activity amongst opticians at the present in the perfection of lanterns for the highest class of scientific and educational demonstration, we need only draw attention to the latest efforts of Messrs. Ross, Limited, in that direction, the various instruments to be described having been put on the market since the earlier chapters of the work were in the press.

Figs. 69 and 70 represent two forms of their new Universal Combination Lantern, designed for the combined purposes of ordinary projection, science work, and enlarging. They are, in fact, intended for the same classes of work as the more expensive Science Lantern described in Chapter XIV.

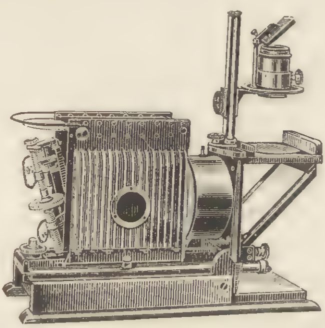


FIG 69.—ROSS' NEW UNIVERSAL COMBINATION LANTERN (ARC LIGHT).

Fig. 69 shows the lantern as arranged for use with the New Model arc light described in Chapter XI., and for vertical projection. It will be noticed that it is fitted with a body of entirely new design, adapted to withstand the intense heat of the most powerful illuminants. This body is constructed of stout blackened brass plates, surrounded by an outer casing of aluminium, by which a most perfect system of ventilation is obtained, and the

heating of the lantern reduced to a minimum. The vertical front can be turned down in an instant when the instrument is required for ordinary projection, or removed altogether and replaced by a bellows extension front when wanted for enlarging purposes; in fact, its uses are universal.

Fig. 70 shows it as fitted for limelight, and with the bellows extension in use. In this form it is built with the patent limelight body described in a former chapter. This entirely encloses

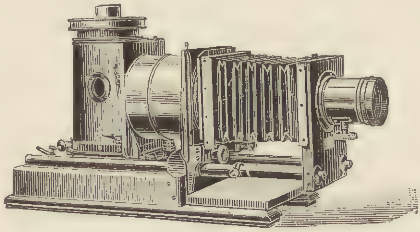


FIG. 70.—ROSS' NEW UNIVERSAL COMBINATION LANTERN (LIMELIGHT).

the mechanism of the jet, with the exception of the taps and lime burner, and is provided with sight holes for examining the light, but has no doors. The entire body can be raised on sliding guides, as shown in the patent enlarging lantern figured in Chapter XXI. As in the alternative form, the front here shown can in a few seconds be removed and replaced by a vertical or open front, and applied to all the purposes required in a science lantern of the highest class with as much ease and comfort as to ordinary projection and enlarging.

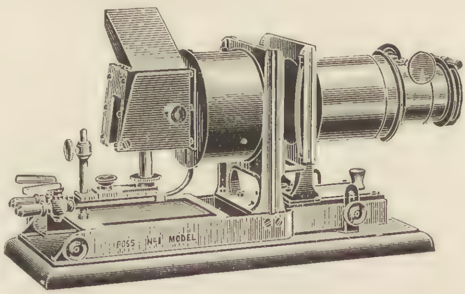


FIG. 71.—ROSS' NEW LIMELIGHT LANTERN (NO. 1 MODEL).

In the newest limelight lantern of the same firm, known as Ross' New Model Limelight Lantern (Fig. 71) the very acme of

compactness would seem to have been reached, and a new departure made in lantern bodies. In this it will be seen that only the light itself—that is the jet-tip and the lime—is enclosed in the metal body, and by this arrangement while the illumination is perfectly confined within the lantern, the small surface of heated metal leads to far less heating of the rest of the apparatus than with other forms of body. The extreme compactness and portability, combined with its moderate price, must recommend this instrument to all who have to carry their apparatus from place to place.

THE RADIANT LIMELIGHT JET.

Messrs. Ross have also introduced a new lime-jet of very high efficiency, to which the above title has been given, and for which a greater intensity of light from a smaller area of lime is claimed with a decreased consumption of gas. The principal feature in this jet is found in the mixing chamber, which is of peculiar shape, and seems well calculated to bear out the claims made for it

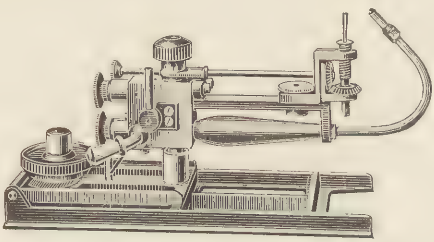


FIG. 72.—ROSS "RADIANT" LIMELIGHT JET.

In addition, it is fitted with every motion possible, and exhibits unusual solidity in its construction combined with elegance of form; and on actual trial we find it a very efficient jet, with a facility and "sweetness" of vertical and horizontal movements not surpassed, if equalled, in any jet we have seen.

INDEX.

THE

KING OF CINEMATOGRAPHS.

The Bioscope.
INVENTED BY C. URBAN. N.Y.
REGISTERED TRADE MARK.

CAMERA & PROJECTOR.

(PATENTED).

2,500 Latest Film Subjects

(COPYRIGHTED).

Best Makes, including LUMIERE, MELIES (Robert Houdin) **and the famous "W.T.C." subjects.**

OPTICAL LAMPS.

Latest Models—HEPWORTH ELECTRIC ARC LAMPS, RHEOSTATS, GWYER LIME LIGHT JETS, CARBONS, LIMES, OBJECTIVES, etc., etc.

All Accessories of Best Quality pertaining to the Cinematograph Trade.

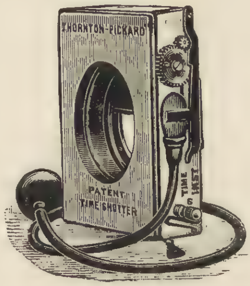
SEND FOR CATALOGUES.

THE WARWICK TRADING CO., Ltd.,

5, Warwick Court, High Holborn, London, W.C.

Telegrams: "Cousinhood, London," Telephone: "1135, Holborn."

THORNTON-PICKARD



CAMERAS AND SHUTTERS

MAKE PHOTOGRAPHY A PLEASURE.

Time and Instantaneous Shutter.

Simplest, Best, and Cheapest.
Largest Sale in the World.
One Shutter will fit two or more Lenses.
Works absolutely without vibration.

Price from 12/6.
SNAP SHOT from 8/-.

Focal Plane Shutter.

For High-Speed Instantaneous Work.

From 35/-.

'Amber' and 'Ruby' Cameras

FOR HAND OR STAND.

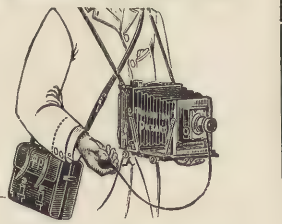
The "**AMBER**" competes with the most expensive in quality and the cheapest in price.

Quarter Plate from £2 13s. 6d.

The "**RUBY**" is Three Cameras in One.

Perfect as a Stand Camera!
Perfect as a Hand Camera!
Perfect as a Stereoscopic Camera!

Half-Plate from £4 2s. 6d.



ILLUSTRATED CATALOGUE POST FREE FROM—

The Thornton-Pickard Manufacturing Co., Ld., Altrincham.

NOAKES & NORMAN

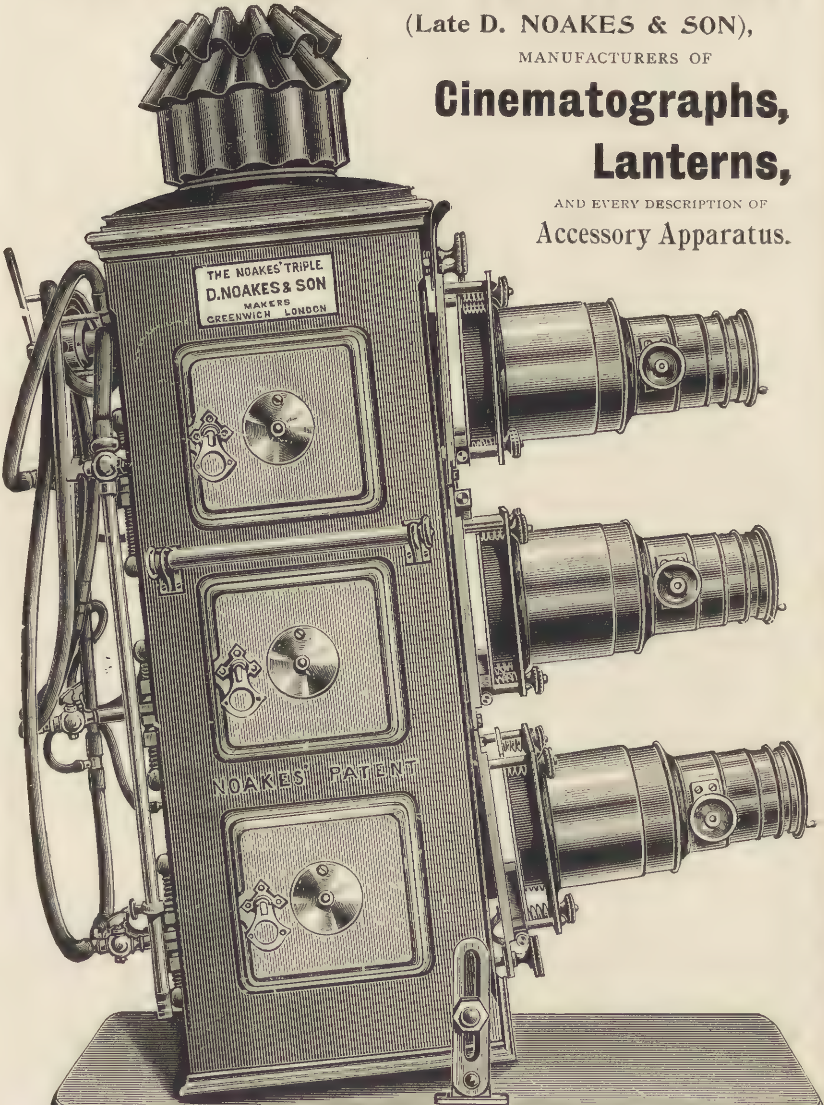
(Late D. NOAKES & SON),

MANUFACTURERS OF

Cinematographs, Lanterns,

AND EVERY DESCRIPTION OF

Accessory Apparatus.



South London Optical Works : Nelson St., Greenwich, London, S.E.

SPECIALITIES :

Dissolving View Apparatus and Patent Triple Dissolver.

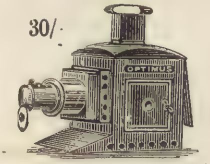
The Magic Lantern: Its Construction and Use—Contains complete Instructions (cloth covers), **Price 6d.**

Trade **'OPTIMUS'** *Mark.*

MAGIC LANTERNS.

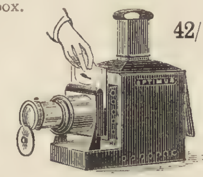
Each Magic Lantern is efficient for exhibitions. The Lens gives crisp definition, being a superior Achromatic Photographic Combination, with rack and pinion. It is fitted to a telescopic lengthening tube, so gaining increased focal accommodation. The Condenser is composed of two plano-convex lenses of four inches diameter. The refulgent lamp has three wicks (or, four wicks, 2s. extra). Each is complete in box.

30/-



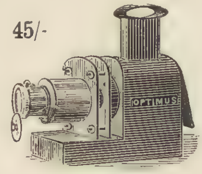
Superior Japanned Metal Body. 2nd Quality, **21s.**

42/-



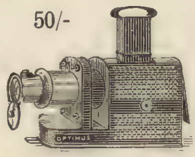
Student's Lantern (to take demonstrating tank), with Brass Sliding Tubes.

45/-



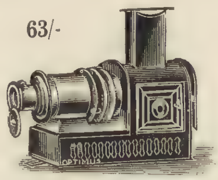
Russian Iron Body, Brass Sliding Tubes.

50/-



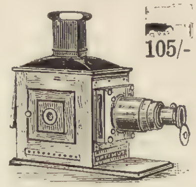
Perforated Russian Iron Body, Brass Sliding Tubes.

63/-

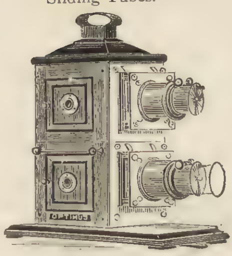


Educational Lantern, Russian Iron Body, Brass Sliding Tubes.

105/-



Mahogany Body, Brass Stage & Sliding Tubes.



LANTERNS FOR LIMELIGHT.

TRIPLE.

Seasoned Mahogany Body, 6 Panelled Doors, Moulded Foot, picked out with black, Brass Stages and Tubes, Achromatic Front Lens, Compound Condensers.

£17 10s. 0d.

BIUNIAL.

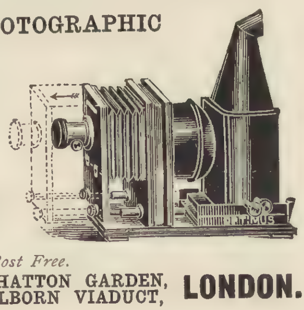
Seasoned Mahogany Body, 4 Panelled Doors, Moulded Foot, picked out with black, Brass Stages and Tubes, Achromatic Front Lens, Compound Condensers.

£10 10s. 0d.

The Top Lantern may be used separately with Oil Lamp.

MAGIC LANTERN TRANSPARENT PHOTOGRAPHS:
Plain, 12s.; Coloured, 18s. 6d. per Dozen.

"OPTIMUS" CANTILEVER PHOTOGRAPHIC ENLARGER.



We are now offering this already popular model, finished in a very superior and practical style. The lamp gives a brilliant and even light. The optical system is throughout of the best. **The Lens will be found to give a very flat field and good marginal definition.** *SUITED FOR POCKET CAMERA (KODAK) NEGATIVES.

Diam. of Condenser .	*4-in.	5-in.	6-in.	8-in	10-in.
Price without Front Lens	**62s.**	**70s.**	**80s.**	**110s.**	**200s.**
Extra for Front Lens .	**27s.**	**37s.**	**63s.**	**63s.**	**105s.**

INCANDESCENT GAS, 7s. 6d. EXTRA.

Catalogue of Apparatus Post Free.

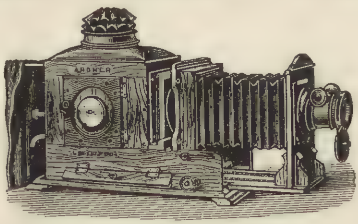
PERKEN, SON & RAYMENT, 99, HATTON GARDEN, HOLBORN VIADUCT, **LONDON.**

ESTABLISHED 1852.

ARCHER & SONS' Improved Optical Lanterns

ANIMATED PHOTOGRAPHS and all Apparatus.

Price, **£8 15s.** complete.



Plainer Finish, **£6 6s.**

TWO PRIZE MEDALS—Liverpool International and Photographic Exhibitions.
Will show to perfection any distance, 1 to 100 feet from Screen.

"THE IDEAL" LANTERN.

THE LANTERN OF THE FUTURE. See enthusiastic Testimonials from Paul Lange, Esq.; F. Anyon, Esq.; G. E. Thompson, Esq.; The Manchester Camera Club, etc., etc.

Our New Patent "IDEAL" Dissolver
FOR SINGLE LANTERNS. Improved Blow-through Safety Jet, 500 c.p. .. **16s.**

The "PHOTINUS" (REGISTERED). Price,
The most powerful Oil Lantern in the World .. .. .. **£4 4s.**

Full-Sized LANTERNS .. .. from **£1 1s.** to **£100**

Illustrated Price Lists, many Novelties, post free, 1d.

One of the finest and largest stocks of **SLIDES** in the Kingdom at most **Reasonable Prices.**

ARCHER & SONS, Manufacturing Opticians, 43, LORD STREET, **Liverpool.**

ESTABLISHED 1848. TELEPHONE No. 5615.

Dark Room for trying Lanterns, etc., on the premises. Workshops on the premises.

PHOTOGRAPHIC CAMERAS and all Accessories.

Photographic Catalogue, 130 Pages, post free, 1½d.

SLIDE PAINTING COLOURS,

Specially Prepared for Painting Magic Lantern Slides.

Just Published, "A Manual on Painting on Glass, and How to use the Magic Lantern." Price 1. each.

In Collapsible Tubes and Glass Pots. Boxes fitted with Varnish Colours, 5s., 15s., and 30s. each; Boxes fitted with Water Colours, 2s., 5s., and 21s. each.

Illustration of 5s. Varnish Box.

Also manufacturers of the New Chromo-Printed Magic Lantern Slides. 4s. per set. 12 Slides. 80 Subjects.

NEW LISTS JUST READY. LISTS POST FREE.

J. BARNARD & SON, Manufacturing Artists' Colourmen,

RETAIL, WHOLESALE, AND EXPORT,

19, BERNERS STREET, LONDON, W., ENGLAND.